An Analysis of Gear Selectivity and Sources of Bias in Estimates of Age and Stock Composition of the 1980 - 1984 Barkley Sound Sockeye Salmon *(Oncorhynchus nerka)* Catch

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AN ANALYSIS OF GEAR SELECTIVITY AND SOURCES OF BIAS IN ESTIMATES OF AGE AND STOCK COMPOSITION OF THE 1980 - 1984 BARKLEY SOUND SOCKEYE SALMON (*Oncorhynchus nerka*) CATCH

by

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ABSTRACT

Steer, G.J., N.B.F. Cousens, H. Stiff and K.D. Hyatt. 1986. An analysis of gear selectivity and sources of bias in estimates of age and stock composition of the 1980 - 1984 Barkley Sound sockeye salmon (Oncorhynchus nerka) catch. Can. Tech. Rep. Fish. Aquat.Sci. No. 1445: 77 p.

Gear selectivity and sources of bias in estimates of age and stock composition are analyzed in the commercial net catch of sockeye salmon (Oncorhynchus nerka) from Barkley Sound, 1980 through 1984. The variance of body length of sockeye in seine caught samples exceeded that for gillnet samples and the mean length of sockeye in gillnet samples tended to exceed that for seine samples. Interaction between the spatial distribution of the fishing fleet and that of the three sockeye stocks present in the fishery, Great Central, Sproat and Henderson, produced significant differences in stock composition between samples collected from openings later in the fishing season. Because samples were not randomly selected, the precision of age and stock composition estimates can only be bounded. If sampling effort remains at 1980-84 levels, random selection of samples is recommended.

RESUME

Steer, G. J., N. B. F. Cousens, H. Stiff and K. D. Hyatt. 1986. Ananalysis of gear selectivity and sources of bias in estimates ofage and stock composition of the 1980 - 1984 Barkley Sound sockeye salmon (Oncorhynchus nerka) catch. Can. Tech. Rep. Fish. Aquat.Sci. No. 1445: 77 p.

L'article qui suit contient une analyse de la sélectivité des engins et des sources d'erreurs systématiques dans les estimations de la composition par âge et par stock des prises commerciales aux filets maillants de saumons nerka (Oncorhynchus nerka) dans le détroit de Barkley de 1980 à 1984 inclusivement. La variance de la longueur du corps des saumons capturés à la senne dépassait celle des échantillons capturés aux filets maillants, et la longueur moyenne des sujets capturés aux filets maillants avait tendance à dépasser celles des échantillons capturés à la senne. L'interaction entre la distribution spatiale de la flottille de pêche et celle des trois stocks de saumons nerka présents dans la pêcherie, Great Central, Sproat et Henderson, produisit des différences significatives de composition de stock entre échantillons recueillis au moment d'ouvertures plus tardives de la saison de pêche. Puisque les échantillons n'ont pas été choisis au hasard, la précision des estimations de composition par âge et par stock ne peut être que limitée. Nour recommandons une sélection d'échantillons au hasard si l'échantillonnage demeure aux même niveaux qu'en 1980-84.

INTRODUCTION

In recent years, the addition of inorganic nutrients to ultraoligotrophic, sockeye-nursery lakes along the coast of British Columbia has emerged as a promising technique for enhancement of sockeye salmon (Oncorhynchus nerka) (Stockner and Hyatt 1984; Hyatt and Stockner 1985). The frequency of use of lake fertilization by the Salmonid Enhancement Program has increased from application to one lake in 1976 to a total of 15 lakes in 1983 (Stephens and Stockner 1983). One objective of the Salmon Stock Assessment Program of the Fisheries Research Branch is to evaluate the increase in production resulting from these sockeye enhancement efforts.

Ideally, this evaluation consists of comparing the stock-recruitment functions of stocks under treatment with those of the same stocks in unfertilized states. Simple comparison of returns from fertilized brood years with those from unfertilized brood years is not sufficient because changes in escapement levels can also affect return strength. Development of a stock-recruitment function requires estimates of brood year escapement and resulting adult returns, comprised of catch plus escapement. In species with multiple age-at-return, the assigning of returns to brood year requires age composition estimates for both escapement and catch. Further, stock composition of catches from mixed stock fisheries are required so that numbers at age can be calculated for each stock. In this study, we examine the assumptions required to estimate these parameters for a mixed stock fishery located on the west coast of Vancouver Island, British Columbia.

Since 1972, the commercial net fishery for sockeye in Barkley Sound (Pacific Fishery Management Area 23) and the escapements to the three sockeye stocks (Great Central Lake, Sproat Lake and Henderson Lake) contributing to that fishery have been monitored. These stocks are of particular interest in evaluating lake enrichment since each lake has been intermittently enriched and their escapements have been closely monitored since 1980. Escapements to Great Central Lake from 1975 to present and to Sproat Lake from 1980 to present were estimated using electronic fish counters and documented calibration procedures. From 1980 to present, mark-recapture estimates of escapements to Henderson Lake are available (K. Hyatt, unpubl. data). Also, the escapements for each stock were routinely sampled for age composition. Thus, estimates of abundance of escapement by age with accuracy and precision estimates can be produced for all three stocks from 1980 to present. Great Central Lake was fertilized each year from 1970 to 1973 and from 1977 to present and Henderson Lake from 1976 to present; treatment of Sproat Lake was initiated in 1985.

Estimation of catch at age by stock for this period is somewhat complicated by the mixed stock, gear, temporal and spatial characteristics of the fishery coupled with a non-random sampling program. Area 23 can be

divided into four major fishing areas; Imperial Eagle and Trevor Channels and Uchucklesit and Alberni Inlets (Fig. 1). Although fishing boundaries fluctuate within and between years (Hyatt and Raymond, in prep), in recent years there has been a tendency for gillnets to fish outside or among seines thus either intercepting or simultaneously fishing stocks subject to seine harvest.

Sockeye bound for the three lakes first pass through either Imperial Eagle or Trevor Channels. Those migrating to Great Central and Sproat Lakes must also pass through Alberni Inlet but Henderson Lake fish likely divert to the lake at the lower end of Alberni Inlet into Uchucklesit Inlet. Sockeye bound for Henderson Lake tend to return later in the season than those bound for Great Central or Sproat Lakes.

The commercial fishery harvests approximately 65% of the total run to Barkley Sound (Fig. 2) and from 1980 through 1984, harvest by seine gear exceeded that by gillnet; harvest by other gear was negligible. Approximately 2/3 of the Barkley Sound catch is transported via fishing vessel, packer or truck to Vancouver where it is processed primarily by B.C. Packers Ltd. (Fig. 3). During transportation, the catches may be mixed at several transfer points as they are collected from the fishing vessels and consolidated for shipment to the processors.

Sampling from 1980 through 1983 consisted of taking one or more samples of 100 fish from a packer or fishing vessel unloading at a cannery (usually B.C. Packers) during or immediately after each fishery opening. Holds could contain fish derived from single sub-areas within Area 23, single gear types (seine, gillnet) or mixtures of both. Because weekly sampling trips were scheduled in advance, sample composition with respect to gear and area depended on availability at the processor. Thus, between weeks, it was most common to obtain single, unreplicated samples from gillnet catches, seine catches and mixed seine and gillnet catches. Commercial fishery samples obtained prior to 1982 were generally unreplicated. In 1982, efforts were initiated to obtain samples replicated with respect to gear type and in 1983 this program was expanded to obtain replicates with respect to both gear type and subarea.

Samples were transported to the laboratory at the Pacific Biological Station for determination of age, sex and parasite incidence.

One objective of the commercial catch sampling program is to supply proportions at age by stock for the commercial catch. A necessary assumption is that the samples taken by the past sampling program are unbiased and therefore representative of the catch from each opening. This assumption had not been tested until 1984 when sampling effort was increased to provide replicate samples to test its validity. Two questions are relevant. First,

are there mechanisms by which the samples could be biased? Second, if the first condition is true, are our samples biased? The most obvious source of bias is gear selectivity.

The selective action of fishing gear on a fish population is a function of the size and morphology of the part of the fish population encountering the gear and the selective, physical characteristics of the gear (Hamley 1975). The selective action of gillnets on sockeye populations is well documented.

Comparative gillnet mesh studies provide indirect evidence for this mechanism. Peterson (1954) observed that mean length-fish, mean weight-fish and the proportion of males increased with mesh size and that males were larger than females for a given mesh size. Wilson and Pearce (1984) also reported that mean weight-fish and proportion of males increased with mesh size. Todd and Larkin (1971) found similar patterns for age 1.2[1] sockeye but no significant patterns for age 1.3 sockeye.

They also reported a decrease in catch of 1.2 sockeye with increasing mesh size but again no catch pattern for age 1.3 sockeye.

Direct evidence of size selectivity comes from studies of gillnet fishery, seine fishery and escapement data. Todd and Larkin (1971) reported that the 1968 Skeena River gillnet fishery caught a greater proportion of sockeye from the middle portion of the length frequency distribution than from the tails when catches were compared with total returns. Peterson (1954) noted that the Fraser River gillnet fishery selected for larger fish and thereby reduced the average length of fish in escapements associated with fishery openings. Killick and Clemens (1963) reached a similar conclusion by comparing mean weight-fish in Fraser River seine and gillnet catches. They also found evidence for sequential exploitation effects; the average weight of sockeye caught decreased as the fish migrated through a series of gillnet and seine fisheries.

Since older fish are generally larger, selection for size should result in selection for age. Gillnets have been found to select for age classes in the Skeena River, Rivers Inlet and Bristol Bay sockeye fisheries. Larkin and MacDonald (1968) reported the ratio of 5 year old to 4 year old sockeye exploitation rates in the 1962 through 1965 Skeena River gillnet fisheries ranged from 1.7 to 2.4. Todd and Larkin (1971) concluded that gillnets on the same system in 1968 selectively removed the largest 4 year

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[1]Age is reported using the European system. The first digit corresponds to the number of winters spent in freshwater and the second to those spent in saltwater.

olds and smallest 5 year olds. Foskett (1958) reported similar results for the 1952 Rivers Inlet gillnet fishery. Mathisen (1971) compared the age composition of the 1919 Nushagak Bay gillnet catch with that from trap samples and found higher proportions of 5 year old and lower proportions of 4 and 6 year old sockeye in the gillnet catch than in the trap samples. Also, age class 1.1 sockeye, jacks, were rarely caught by gillnets but were found in escapements (Milne 1955; Foskett 1958; Manzer 1976). Purse seines, usually assumed to be non-selective, have selection characteristics different from those of gillnets (Holt 1963; Killick and Clemens 1963).

Given the spatial and temporal characteristics of the Area 23 gillnet and seine fisheries and the differences between gillnet and seine selectivity, the age and stock composition of single samples taken between weeks could differ due to four effects. First, there could be real changes in the age and stock composition of the sockeye population in Area 23. Second, gear type could be important because the selective action of a gillnet differs from that of a seine when deployed to intercept identical populations of fish. Third, the length frequency distribution and age composition of the sockeye population encountering the seine fishery may be altered by the selective action of the gillnet fishery. Fourth, fish bound for Henderson Lake must pass through the two outside channels but may not pass completely through Alberni Inlet.

To determine whether there is evidence for gear selectivity in Area 23, we analyse paired gillnet and seine samples for differences in mean length and variance in length.

To determine whether the last three effects affect the age and stock composition data, we analysed for bias replicate samples collected from 1980 through 1983 and those from an intensive sampling program in 1984. Samples were taken from many sources with characteristics that form a hierarchy of effects that could potentially create detectable differences. For example, samples taken from the same hold should be more similar than those taken from holds containing fish caught by different gear types. If samples with the greatest potential differences are not significantly different, then we conclude that the mixing that occurs between the fishing grounds and the processor, where the samples are drawn, is sufficient to eliminate bias.

METHODS

Samples from the Area 23 commercial net fishery for sockeye were collected and processed using standard methods (K. Hyatt, unpubl. data) under the supervision of one of us (Cousens) to ensure continuity from 1980 through

1984. Summary descriptions of samples used in this study are found in Table 1.

Sockeye are assigned to stock using Myxobolus sp. and Henneguya sp. parasite incidence data as follows. (L. Margolis, DFO/PBS, Nanaimo, B.C., pers. comm.). If Myxobolus is absent, the sockeye are assigned to Great Central Lake. If Myxobolus and Henneguya are present, the fish are assigned to Henderson Lake and if only Myxobolus is present, the fish are assigned to Sproat Lake. Sockeye from openings early in the fishery were not examined for Henneguya infestation, so those with Myxobolus parasites are assigned to the Sproat Lake stock. The algorithm is based on the observation that smolts from Great Central Lake do not carry Myxobolus parasites while smolts from Sproat and Henderson Lakes do. Only those from Henderson Lake carry Henneguya. The stock discrimination algorithm is not perfect as the incidence of Henneguya infection in Henderson smolts is between 85 and 100% but it is sufficient for testing sample homogeneity and is of interest to fishery managers.

In the first part of the analysis, we evaluate two measures of gear selectivity, variance in length and mean length. If the gillnet fishery is selective for the midrange of the sockeye size distribution (Todd and Larkin 1971), then for some openings the variance of the size distribution of the sockeye population encountering the seine fleet, having already been filtered by the gillnet fishery, should be greater than that encountering the gillnet fleet. Also, if the two fleets simultaneously fish the same population, the variance of a gillnet caught sample should be less than that of a seine caught sample due to the sampling characteristics of the two nets. Either or both of these mechanisms should result in the variance in length of a sample from the Area 23 seine catch exceeding that from the Area 23 gillnet catch. A Mann-Whitney U statistic (Klugh 1974) is used to detect differences in variances of gillnet and seine samples taken from openings where both types of samples are available to test this hypothesis, i.e.

$$H_1 : \mathrm{Var}(\text{length,seine}) \neq \mathrm{Var}(\text{length,gillnet})$$

It is frequently observed that the mean weight-fish of the commercial gillnet catch of sockeye exceeds that of the commercial seine catch (e.g. Ricker 1982; Peterson 1954; Killick and Clemens 1963). This observation has also been made for Area 23 (D. Girodat, DFO, Port Alberni, B.C., pers. comm.). An ANOVA, blocked by fishery opening, is performed on ranked post-orbital to hypural lengths from openings with both gillnet and seine samples to test for a gear effect on size, i.e.

$$H_1 : \text{length(seine)} \neq \text{length(gillnet)}$$

The data are ranked because the variance of length samples from seine catches may exceed that from gillnet catches and blocked to control for between-opening changes in population characteristics.

In the second part of the analysis, we examine assumptions concerning gear selectivity, the interaction of the fishery and the sockeye stocks and potential bias implicit in the sampling program. These factors follow from the way fish are collected on the fishing grounds, transported, processed and sampled.

Fishing vessels usually unload their catches to packing vessels or trucks which transport the catch to processors. When catches are low, the major processors each use one packer or fishing vessel to pack the fish. Vessel holds may be filled with a mix of seine and gillnet caught fish to maintain vessel trim. When catches are high, multiple packers may be used, leaving the grounds at different times during or after the opening and collecting fish from different fishing areas within Area 23. There is then a greater opportunity to separate catch by gear and location among holds.

Transport vessels are unloaded one hold at a time using a fish pump and the contents are sorted to species and occasionally graded prior to sampling. The first 100 or so fish are sampled and then returned to the processing line before the hold's contents are completely processed, unless the sample is purchased for parasite analysis.

There are six potential factors that could produce significant between-sample differences in stock and age composition. They are arranged in approximate order from least to greatest potential effect. A seventh factor, the presence of netmarks, is added because it may enable partitioning of mixed gear samples into subsamples by gear type.

1. Processing Line Bias. The first 100 fish taken from a packer hold is an unbiased sample of the hold contents, i.e. there is no last in/first out bias.

2. Higrade Bias. Samples taken after the fish are sorted to species and grade are representative of all sockeye from the hold. Occasionally, sockeye are sorted to grade prior to sampling and the "higrade" fish removed from the line.

3. Between-hold, within-packer, within-processor, within-gear bias. A sample from one hold is representative of other holds on the same packer containing fish caught by the same gear type.

4. Between-packer, within-processor, within-gear bias. A sample from a packer delivering fish caught from the start of a fishery opening is representative of fish caught by the same gear type and delivered by a different packer later in the same opening. Different packers may also deliver fish caught by the same gear-type but from different locations within Area 23.

5. Between-processor, within-gear bias. A sample from a packer delivering to one processor is representative of fish caught by the same gear type but delivered by a different packer to a different processor.

6. Between-gear bias. A sample from a hold containing seine caught fish is representative of fish caught by gillnet.

7. Netmarks. Samples taken from mixed gillnet and seine holds contain fish with netmarks that may indicate that the fish were gillnet caught.

These assumptions form a progression of effects that together could invalidate analyses that simply assume the age and stock composition estimates from any Area 23 commercial fishery sample are unbiased.

The experimental design for testing these assumptions consists of separately comparing the age and parasite composition of multiple samples collected during each fishery opening using a chi-square test for marginal homogeneity. An overall chi-square statistic is calculated for each opening to test the hypothesis that the true response probabilities are the same across all samples. If the overall chi-square is significant and there are more than two samples, pair-wise chi-squares are used to distinguish different samples. Because each opening may have comparisons involving multiple hypotheses, the results from the comparisons grouped by opening are then recombined by hypothesis. The analysis is first performed by opening to control for between-opening changes in population characteristics. To reduce the likelihood that the significant cases are due simply to chance, the rejection rate is compared with that expected by chance using a binomial distribution (Ott 1977).

It would be better to use age by stock categories for these analyses since the samples will ultimately be used to assign catch to stock and age. However, the number of categories in each sample would increase from two or three for stock composition and five or six for age composition to between ten and eighteen for both age and stock. The average number of observations per cell would then drop and make the proportion of cells with expected counts less than five greater than the 20% maximum criterion suggested by Cochran (1954).

The design is weakened by the lack of replication within some treatment units (Hurlbert 1984). For example, a single gillnet sample may differ from a single seine sample due to sample effects alone. There is usually no estimate of within gear-type variability to separate within-cell from between-cell effects. However, the lack of replication creates a problem only with the interpretation of significant differences. If the null hypothesis is not rejected, there is obviously no need to ascribe the difference to an effect.

RESULTS

The variance of hypural length of sockeye in seine caught samples exceeded that for gillnet samples and the mean length of sockeye in gillnet samples tended to exceed that for seine samples. Interaction between the spatial distribution of the fishing fleet and that of the three sockeye stocks present in the fishery, Great Central, Sproat and Henderson, produced significant differences in stock composition between samples collected from openings later in the fishing season.

Histograms of length frequency for samples used in the variance of post-orbital to hypural (POH) length and mean POH length analyses are found in Appendix I, Figures 1 through 5.

Variances of POH lengths in seine samples are significantly ($p<0.01$) greater than those in gillnet samples from openings where both types of samples are available (Table 2). This result recommends the use of rank transformations to homogenize the length variances and permit the use of ANOVA to test for differences in mean length due to gear type. Ranking reduces the ratio of maximum variance to minimum variance across all seine and gillnet samples used in the ANOVA from 3.71 to 1.79.

The ANOVA on ranked POH lengths produces significant gear ($p=0.0135$) and opening ($p=0.0001$) effects (Table 3). Mean lengths of fish in gillnet samples are greater than those in seine samples from the same opening for three openings, intermediate between those in two seine samples for one opening and slightly less than that in a seine sample for one other opening. Overall, mean length of fish in gillnet samples exceeds that in seine samples. The opening effect, comprised of both within-year and between-year effects, shows no consistent pattern but its significance supports the use of blocking by opening to control for seasonal changes in population characteristics. Results from both analyses indicate that the seine and gillnet fleets in Area 23 have different selection characteristics.

Histograms of stock and age composition for each sample used in the analysis of sample homogeneity are grouped by opening in Appendix II, Figures 1 through 15.

Four of 15 openings with replicate stock composition samples and 6 of 18 openings with replicate age composition samples show significant between sample differences (Table 4). Given an alpha level of 0.05, the binomial probability of 4 or more rejections in 15 trials is 0.0055 and of 6 or more rejections in 18 trials is 0.00017. Some or all of the age and stock composition rejection results are not simply due to chance. Pairwise chi-square comparisons to distinguish samples for openings with significant overall chi-squares and more than two samples are presented in Table 5. The

results from Tables 4 and 5 are then recombined by hypothesis and binomial probabilities for observed rejection rates calculated in Table 6.

No significant differences in either age or stock composition are found among three samples taken in different ways from a single processing run or between paired samples taken from different holds on a packer or on a seiner. Higrade samples have significantly different age compositions from those taken in the usual way; in both cases the proportion of age 1.3 sockeye is greater in the higrade sample than in the corresponding regular sample.

The age composition of pure or mixed gear samples does not significantly differ between-packer, within-gear-type. There is also no significant difference between-packer in stock composition for either a single comparison of pure gillnet samples or comparisons of mixed gear samples. However, there are between-packer differences in the stock composition of seine samples from the last openings in 1983 and 1984.

All three seine samples from the 25 July 1983 opening are significantly different from each other and were taken from different locations within Area 23: lower Alberni Inlet, Stamp Narrows and Polly Point. The proportion of Henderson sockeye in the samples decreases as sample location moved inward from lower to upper Alberni Inlet or seaward into the gillnet area outside. Gear restrictions for this fishery resulted in gillnets fishing outside, primarily in Trevor Channel, and seines fishing in Alberni Inlet with Uchucklesit Inlet closed to both gear types (Hyatt and Raymond, in prep). The ratio of Great Central sockeye to Sproat sockeye increases from ~1 for the gillnet and lower Alberni Inlet samples to ~2 for the two samples from upper Alberni Inlet.

The same spatial patterns in stock composition are evident in samples from the 16 July 1984 opening. The seine sample from upper Alberni Inlet has a lower proportion of Henderson sockeye than either of the seine sample from lower Alberni Inlet or the mixed gear sample which are similar. As in the 1983 samples above, the ratio of Great Central sockeye to Sproat sockeye in the samples ranges from 1.3 for the lower Alberni Inlet seine and mixed gear samples to two for the seine sample from upper Alberni Inlet.

The lone between-processor comparison of seine samples does not reveal age composition differences; stock composition data are not available.

Two of seven between-gear comparisons of stock composition and three of nine between-gear comparisons of age composition are significant. Both rates of rejection are significant indicating that some or all of the significant differences are not simply chance occurences. The significant between-gear difference in stock composition from 25 July 1983 was discussed above. The other significant stock comparison is from the 08 July 1984 fishery during which gillnets were restricted outside to Imperial Eagle and Trevor channels and seines were restricted inside to Alberni and Uchucklesit

inlets. Differences in stock composition for this opening are largely due to Henderson sockeye, 22% in the seine sample and 5% in the gillnet sample.

Both gillnet samples from the 04 July 1982 opening are different in age composition from the single seine sample but not from each other. Only one of three gillnet versus seine comparisons from the 25 July 1983 is significant. Selection for older age classes is not apparent but jacks are not found in these gillnet samples.

Differences in age or stock composition are not significant between gillnet and mixed gear subsamples containing fish either with or without netmarks nor between these subsamples. Some seine samples differ in stock composition from subsamples of fish without netmarks, primarily due to differences in proportion of Henderson sockeye, but not in age composition. The reverse is true when seine samples are compared with subsamples of fish with netmarks. All significant comparisons using netmark subsamples involve a single netmark subsample from the 01 July 1984 opening so the results simply indicate that this subsample is unique.

DISCUSSION

The effects of gear selectivity are apparent in samples from the Area 23 commercial fishery. Variance of length in seine samples is greater than that in gillnet samples and mean length in gillnet samples tends to exceed mean length in seine samples. These results are consistent with those reported elsewhere (e.g. Peterson 1954; Todd and Larkin 1971; Killick and Clemens 1963; Ricker 1982). However, this gear selectivity does not produce consistent, detectable differences in age composition between-gear except that age 1.1 sockeye are found in seine samples but not in gillnet samples.

There is no detectable bias due to present methods of sampling transport vessels once they have arrived at the processsing plant provided sockeye grading and removal prior to sampling does not occur. Differences in age composition between higrade and normally collected samples are significant. Therefore, sampling should take place before higrading but if it occurs, estimates of the amount removed should be made and additional samples taken. Procedures for obtaining samples, once the vessel and hold is selected, are adequate but selection of which packer or truck to sample is important.

Interactions between the spatial distribution of the fishing fleet and the Area 23 stocks may result in significant differences in stock composition both within and between gear types late in the fishing season. Replicate samples from catches by a single gear type were not available from the early openings so the temporal extent of these differences is unknown. The effect seems to be primarily due to catch location within Area 23. To reduce the chance of systematic bias, care should be taken to randomly sample the catch so that unbiased estimates of age and stock composition and their precision can be calculated. This is only possible if replicate samples are taken. If sampling effort is increased, a stratified sampling scheme by subarea or gear type may be implemented to improve sampling efficiency. Unfortunately, much of the information required to do this, i.e. catch by subarea, is presently not collected. Also, obtaining specified samples from packers at the cannery is rarely possible so sampling would likely have to take place on the fishing grounds with attendant increases in cost.

The interpretation of stock and age composition estimates and their variances for samples already collected is not straightforward because samples were not randomly selected and were infrequently replicated. However, minimum and maximum estimates of variance for a single, unreplicated sample of 100 sockeye can be calculated using the 29 July 1983 fishery as an example. Samples from this fishery were drawn from both gear types over a wide range of locations at a time in the run when all three stocks were present so differences in stock composition between samples should be maximal. The mean proportion of Great Central fish in the four samples is 0.53, of Sproat fish is 0.36 and of Henderson fish is 0.11, with variances of 0.021, 0.0019 and 0.011, respectively. Since these samples were selected to maximize between-sample differences in stock composition, these variances should constitute an upper limit. Using the normal approximation to the binomial, a sample size of 100 and the mean proportions, the variances are 0.0025, 0.0023 and 0.0010, respectively. This calculation assumes that the fish were randomly selected from the Area 23 catch. In fact, the fish in the sample were selected from a single hold, a subset of the Area 23 catch, and this variance does not include a gear-area component. Therefore, these values are underestimates and form a lower limit to the variance.

Upper and lower limits to the actual variance can also be calculated for the stock and age proportions. For example, the mean proportion of age 1.2 Great Central sockeye in the samples from the 23 July 1983 fishery is 0.36 with variance 0.015. The variance using the normal approximation to the binomial and assuming random sampling is 0.0023. These values indicate the range of variance possible for a single, unreplicated sample of 100 fish.

The actual variances are difficult to assess since samples were often not replicated and those that were replicated were not randomly selected and so may be biased. A low variance calculated from replicate samples could

indicate that the catch was well mixed, the samples were effectively random and the estimates are unbiased or it could indicate that the samples were drawn from some homogeneous subgroup of the catch and the estimates are biased. However, samples taken from openings at the beginning of the fishing season when catches are small and only Great Central and Sproat sockeye are present in the fishery should have true variances that tend to the lower bound because there is greater opportunity for mixing as loads are consolidated for efficient transportation. Those taken near the end of the fishery when catches are large and all three stocks are present should have true variances that tend to the upper bound.

Allocating catch to stock and brood year is one component of the estimation of returns. Return data and stock recruitment functions are used by the EAU to evaluate net benefits due to lake fertilization. They also assist fishery managers in the setting of escapement goals and provide a basis for forecasting returns. Returns at age can be used to reforecast expected returns from the same brood year in subsequent years (Peterman 1982). Inseason stock and age information for the commercial catch can be used to evaluate and modify management actions designed to protect certain stocks and with inseason escapement information to calculate return estimates.

Improvements in the precision and accuracy of age and stock composition parameters for the Area 23 commercial sockeye catch may be necessary if they are to be used in these analyses. Due to the presence of identified sources of bias, this may not be a simple matter of increasing sample size. Their presence makes the estimation of the precision of single samples, such as those collected from this fishery, difficult. Future programs should ensure that samples are randomly selected and replicated to enable direct calculation of sample precision and therefore simplify program evaluation.

ACKNOWLEDGMENTS

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Table 1. Summary sample descriptions. Opening date refers to date fishery opened and sample date to date packer/truck left fishing grounds. Sample is sample number. Total sockeye is total sockeye on board vessel/truck. Missing information is indicated by ?.

Year	Date	Sample	Packer	Total sockeye	Gear	Notes
	Open Sample					
1980	14Jul 16Jul	6	Norking	26000	sn	Lower Alberni Inlet near Pocahontas Point
		7	George McKay	14000	gn/sn	Trevor Channel/mostly gn
1981	13Jul 17Jul	6	Kimsquit	?	sn/gn	Mixed
		7	a seiner	?	sn	
	20Jul 24Jul	8	Shogun	?	sn/gn	Mixed
		9	?	?	sn	Alberni Inlet/BCP Port Alberni
1982	07Jun 10Jun	1	Chief Skugaid	4400	sn	
		2	Pakalot	4500	gn	
	14Jun 17Jun	3	Shogun	11000	sn/gn	Mostly sn/few gn deliveries
		4	Shogun	11000	sn/gn	Higrade sample
	21Jun 24Jun	5	?	?	sn	
		6	?	?	sn	Higrade sample
	04Jul 07Jul	8	Lady Jacqueline	?	gn	Trevor Channel
		9	Moon Child	?	gn	Trevor Channel
		10	Pacifc Ocn	?	sn	Alberni Inlet
1983	06Jun 09Jun	1	Chief Skugaid	2000	sn/gn	Mostly seine
		2	Pakalot	4000	gn/sn	Mostly gillnet
	13Jun 16Jun	3	Pakalot	3400	sn/gn	Mostly seine
		4	Chief Skugaid	12400	gn/sn	Mostly gillnet
	20Jun 23Jun	5	Pakalot	21000	gn/sn	Mostly gillnet
		6	Chief Skugaid	20000	sn/gn	Mostly seine
	27Jun 02Jul	7	Hesquiat	40000	gn/sn	Mostly gillnet
		8	Pakalot	16000	sn/gn	Half seine / half gillnet
	25Jul 29Jul	11	gillnets	?	gn	From Pacific Rim Seafoods
		12	ALH/a sn	?	sn	Lower Alberni Inlet
		13	ALH/a sn	?	sn	Upper Alberni Inlet (Stamp Narrows)
		14	Pacific Ocean	?	sn	Upper Alberni Inlet (Polly Point)

Table 1 (cont'd)

Year	Date Open	Date Sample	Sample	Packer	Total sockeye	Gear	Notes
1984	03Jun	07Jun	1	Western	2000	gn/sn	Start of unloading
			2	Star	"	"	End of unloading
			3	" "	"	"	"Random" throughout unloading
	17Jun	20Jun	5	Pakalot	10357	gn	Truck from Ucluelet
			6	Shogun	10972	sn/gn	Truck from Port Alberni
	24Jun	28Jun	7	Western Star	17265	gn/sn	Hold #2 / Mostly gillnet
	01Jul	04Jul	9	Norking	12186	sn	
		05Jul	10	Pakalot	8266	gn	
			11	Western Star	22498	sn/gn	Mostly seine
		06Jul	12	Miss Crewe	15039	sn	CanFisCo
	08Jul	10Jul	13	WG-401	7000	gn	
			14	Cape Pine	18000	sn	CanFisCo / 2 samples of 50 from forward holds
	16Jul	18Jul	15	Western Star	15350	sn	Lower seine area
			16	Canadian Pine	16538	sn	Upper seine area
			17	Norking	14521	sn/gn	Mostly seine

Table 2. Mann-Whitney U Test for differences in variance of ranked seine and gillnet POH lengths. Fishery date is date of opening.

		Seine		Gillnet	
Year	Fishery date	Sample number	Variance	Sample number	Variance
1982	17 June	1	1045.34	2	815.46
	04 July	10	2931.40	8	880.87
				9	879.44
1983	25 July	12	2176.26	11	802.27
		13	1280.75		
		14	1060.76		
1984	01 July	9	1816.47	10	963.60
		12	1481.95		
	08 July	14	1726.49	13	1039.97

Mann-Whitney Statistic = min(0, 48) = 0

$U_{table(6,8,\alpha=0.01)} = 4$

$p < 0.01$

Table 3(a). ANOVA table of ranked POH lengths for gillnet and samples from openings where both types are available. Results for opening and gear nested within opening are shown in the table below.

Source	df	SS	MSE	F	pr>F
Model	9	12911267	1434585	8.30	0.0001
Error	1463	252925629	172881		
Total	1472	265836897			

Source	df	Type III SS	F	pr>F
Fishdate	4	9374522	13.56	0.0001
Gear(Fishdate)	5	2491407	2.88	0.0135

Table 3(b). Mean POH lengths (mm) of sockeye by gear for each opening and overall for samples from openings where both gear types were sampled.

		Seine		Gillnet	
Year	Fishery date	Sample number	Mean	Sample number	Mean
1982	07 June	1	478.1	2	481.3
	04 July	10	448.8	8	471.2
				9	461.1
1983	25 July	12	459.0	11	467.5
		13	459.8		
		14	449.0		
1984	01 July	9	452.7	10	460.2
		12	462.2		
	08 July	14	467.7	13	466.3
Overall			458.4		467.9

Table 4. Age and stock overall chi-square sample composition comparisons. Date is date of fishery opening. "No." is sample number.

						Stock			Age		
Year	Date	No.	Sample type	n	Comparison	df	X^2	p	df	X^2	p
1980	14Jul	6	Sn	100	Netmark	2	5.00	0.08	5	11.42	0.04
		7	Mxd NoNmk	49	Seine						
1981	13Jul	6	Mxd NoNmk	89	Netmark	4	9.23	0.06	8	2.58	0.96
			Nmk	8	Seine						
		7	Seine	97							
	20Jul	8	Mxd NoNmk	98	Netmark	2	16.02	<.001	5	5.14	0.40
		9	Seine	99	Seine						
1982	07Jun	1	Seine	100	Gear	-	-	-	3	0.19	0.98
		2	Gillnet	99							
	14Jun	3	Regular	97	Grade	-	-	-	4	17.29	.002
		4	Higrade	44							
	21Jun	5	Regular	97	Grade	-	-	-	4	16.65	.002
		6	Higrade	47							
	04Jul	8	Gillnet	96	Gear	4	2.43	0.66	10	36.12	<.001
		9	Gillnet	91							
		10	Seine	190							
1983	06Jun	1	Mxd Sn/Gn	92	Mixed	1	1.38	0.24	3	3.30	0.35
		2	Gn/Sn	96	gear						
	13Jun	3	Mxd Sn/Gn	94	Mixed	1	0.001	0.98	3	4.43	0.22
		4	Gn/Sn	98	gear						
	20Jun	5	Mxd Gn/Sn	97	Mixed	1	0.083	0.77	4	5.95	0.20
		6	Sn/Gn	91	gear						
	27Jun	7	Mxd Gn/Sn	94	Mixed	1	0.20	0.66	4	9.28	.054
		8	Gn/Sn	96	gear						
	25Jul	11	Gillnet	95	Gear	6	38.16	<.001	15	31.97	.006
		12	Seine Lwr	98	Hold						
		13 /	Seine Upr	67							
			Stamp								
		14	Seine Upr	98							

Table 4 (cont'd)

Year	Date	No.	Sample type	n	Comparison	Stock df	Stock X^2	Stock p	Age df	Age X^2	Age p
1984	03Jun	1	Start	98	Processing	2	3.33	0.19	6	1.70	0.94
		2	Finish	98	Line						
		3	Random	95							
	17Jun	5	Gn	99	Netmark	2	0.55	0.76	6	7.88	0.25
		6	Mxd NoNmk	103	Gillnet						
			Nmk	42							
	24Jun	7	Mxd Hold2	98	Packer Hold	1	1.52	0.22	3	2.92	0.40
		8	Hold1	99							
	01Jul	9	BCP Sn	96	Netmark	2[a]	0.49	0.78	16	27.13	0.04
		10	BCP Gn	97	Gear						
		11	Mxd NoNmk	61	Processor						
			Nmk	36	Date						
		12	CFC Sn	90							
	08Jul	13	BCP Gn	91	Gear	2	11.18	.004	3	0.56	0.90
		14	CFC Sn	95	Processor						
	16Jul	15	Sn - Lwr	89	Netmark	6	28.81	<.001	12	19.57	0.08
		16	Sn - Upr	99	Seine						
		17	Mxd NoNmk	46	Location						
			Nmk	50							

[a]Henneguya sp incidence data are not available for samples 11 and 12 from 05 and 06 July 1984 thereby preventing Sproat and Henderson stock discrimination so these samples are not included in the stock composition analysis.

Table 5. Chi-square probabilities for pair-wise sample comparisons from openings with significant overall chi-square values. Sample numbers are indicated; see Table 1 for full descriptions. Date is date of fishery opening.

Stock 25Jul83		Lwr Sn s12	Upr Sn/St s13	Upr Sn/PP s14
	Gn s11	0.081	0.24	<0.001
	Lwr Sn s12	-	0.002	<0.001
	Upr Sn/St s13	-	-	0.022

Stock 16Jul84		Lwr Sn s15	No Nmk s17	Nmk s17
	Upr Sn s16	<0.001	<0.001	0.011
	Lwr Sn s15	-	0.70	0.20
	No nmk s17	-	-	0.13

Age 04Jul82		Gn #2 s9	Sn s10
	Gn #1 s8	0.10	0.003
	Gn #2 s9	-	0.001

Age 25Jul83		Lwr Sn s12	Upr Sn/St s13	Upr Sn/PP s14
	Gn s11	0.14	0.35	0.016
	Lwr Sn s12	-	0.12	<0.001
	Upr Sn/St s13	-	-	0.25

Age 01Jul84		BCP Gn s10	No Nmk s11	CFC Sn s12	Nmk s11
	BCP Sn s9	0.15	0.60	0.67	0.009
	BCP Gn s10	-	0.71	0.67	0.041
	No Nmk s11	-	-	0.40	0.030
	CFC Sn s12	-	-	-	0.020

Table 6. Sample comparisons grouped by hypothesis. Total number of comparisons (#), number significant (sig) and binomial probability of chance rejection given ∝=0.05 are shown for both stock and age comparisons.

Comparison	Gear type	Stock			Age		
		#	sig	p	#	sig	p
1. Processing line	Mixed	3	0	1.00	3	0	1.00
2. Grade	Mixed	-	-	-	2	2	0.0025
3. Between-hold	Mixed, seine	2	1	0.098	2	0	1.00
4. Between-packer, within-gear type, within-processor	Mixed	4	0	1.00	4	0	1.00
	Seine	3	3	<0.0002	3	1	0.14
	Gillnet	1	0	1.00	1	0	1.00
5. Between-processor, within-gear	Seine	-	-	-	1	0	1.00
6. Between gear	Seine vs gillnet	7	2	0.044	9	3	0.0084
7. Netmark	Seine vs no netmark	5	2	0.023	7	1	0.30
	Seine vs netmark	3	1	0.14	5	2	0.023
	Gillnet vs no netmark	1	0	1.00	2	0	1.00
	Gillnet vs netmark	1	0	1.00	2	1	0.098
	Netmark vs no netmark	3	0	1.00	4	1	0.19

FIGURES

Fig. 1. Barkley Sound showing relation of primary net fishing areas, Imperial Eagle and Trevor Channels and Uchucklesit and Alberni Inlets to major sockeye nursery lakes.

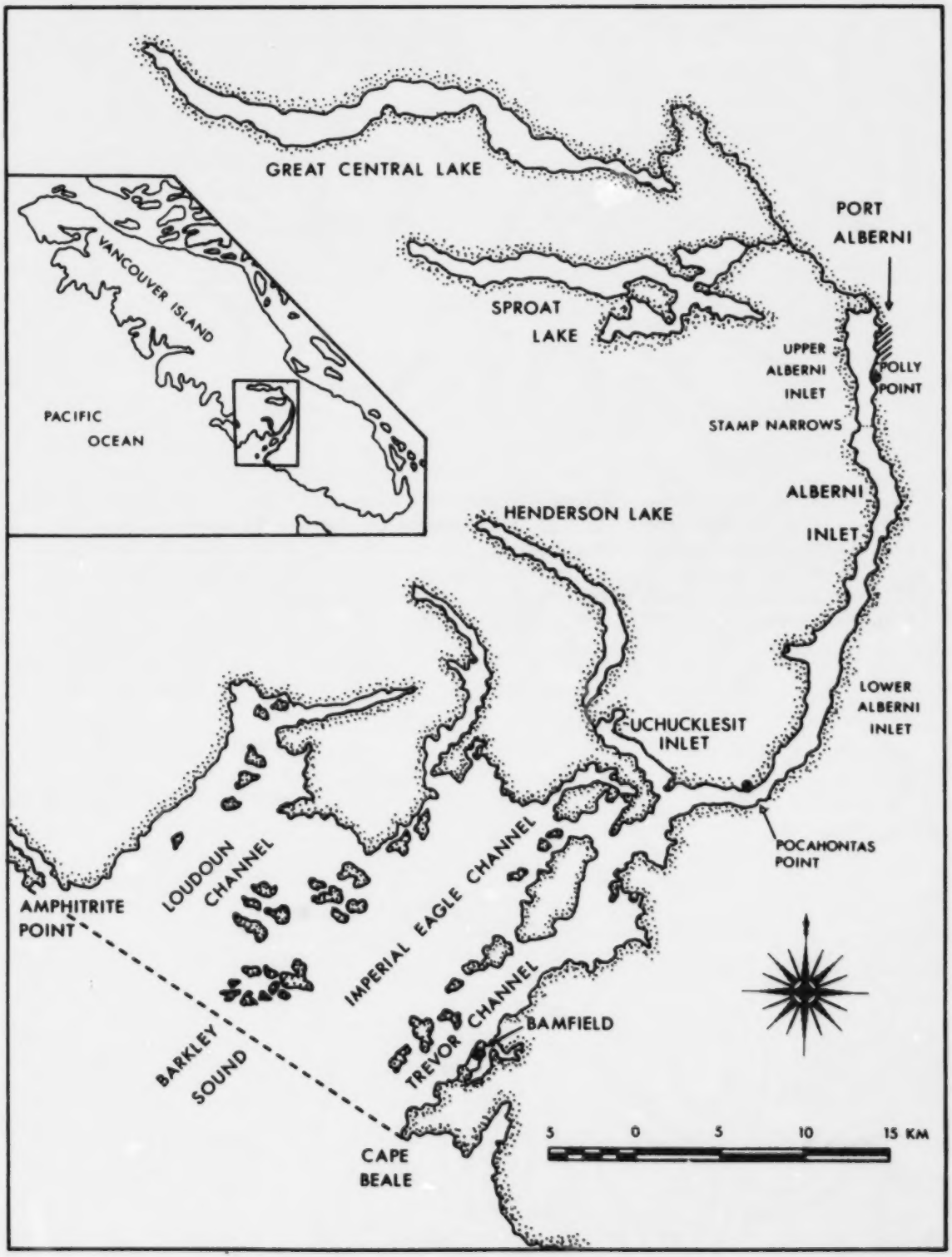

GREAT CENTRAL LAKE
PORT ALBERNI
SPROAT LAKE
VANCOUVER ISLAND
PACIFIC OCEAN
UPPER ALBERNI INLET
POLLY POINT
STAMP NARROWS
ALBERNI INLET
HENDERSON LAKE
LOWER ALBERNI INLET
UCHUCKLESIT INLET
POCAHONTAS POINT
LOUDOUN CHANNEL
IMPERIAL EAGLE CHANNEL
AMPHITRITE POINT
TREVOR CHANNEL
BAMFIELD
BARKLEY SOUND
CAPE BEALE
5 0 5 10 15 KM

Fig. 2. Area 23 sockeye escapement and catch by gear type. For 1980 through 1983, yearly catches are calculated by summing weekly catches from the DFO sales slip salmon landings database (F. Wong, DFO/PBS) for Area 23 during weeks when the Barkley Sound sockeye fishery was open. Estimated seine and gillnet catches for 1984 were provided by D. Girodat (DFO/Port Alberni). Escapements from EAU (DFO/PBS), unpubl. data.

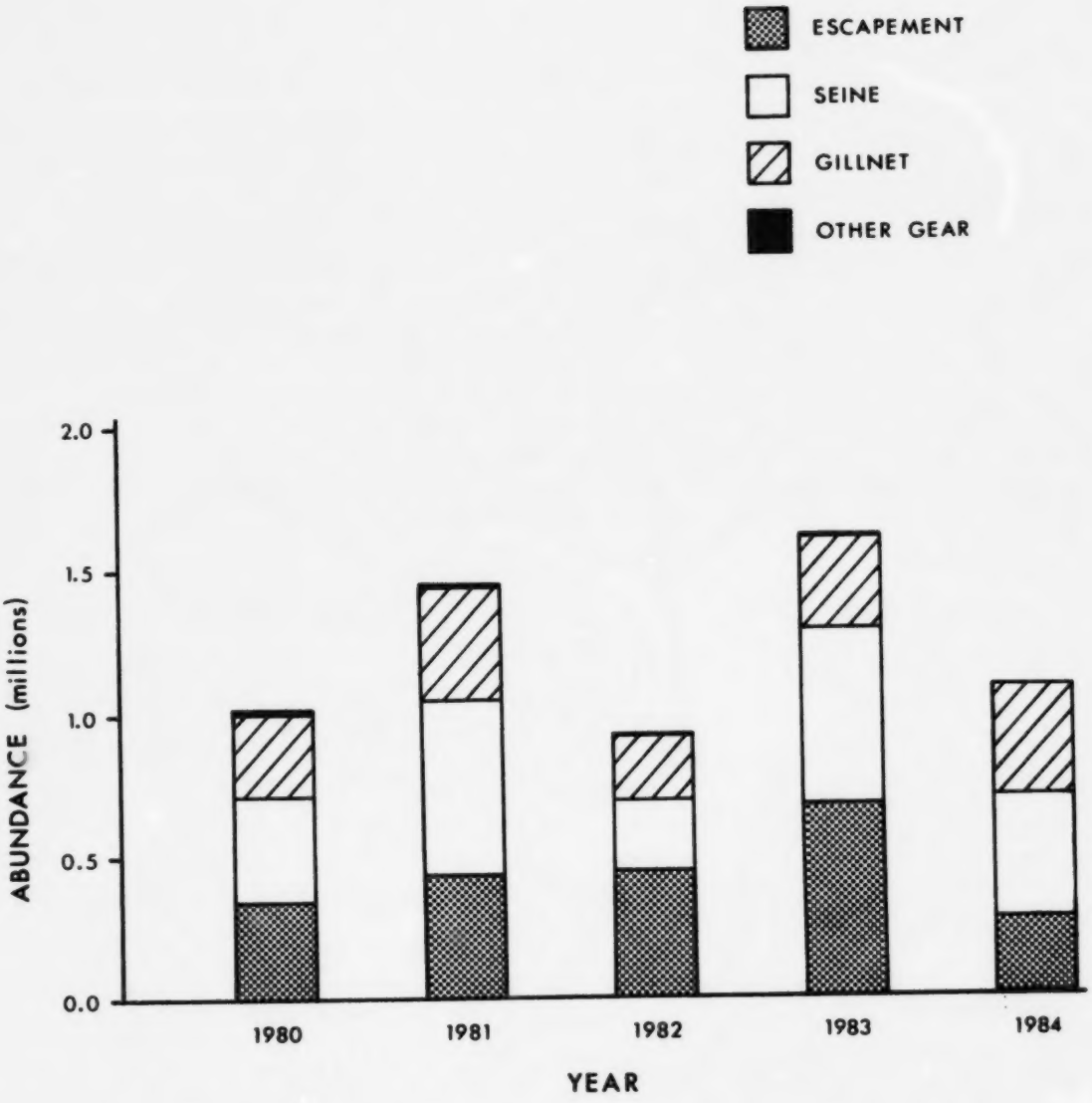
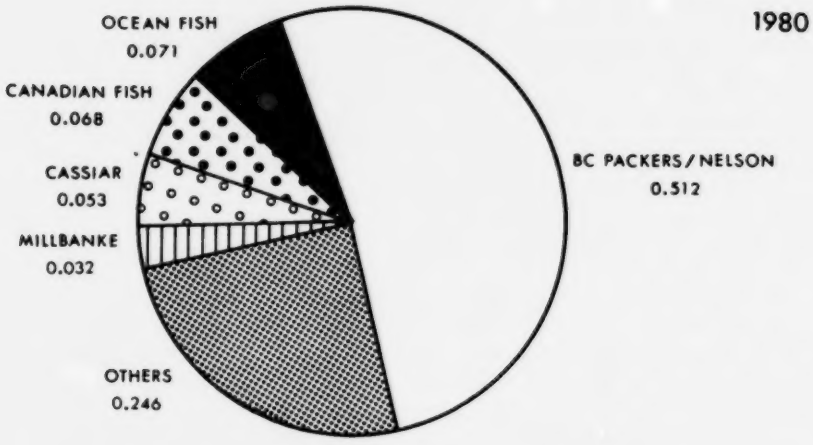
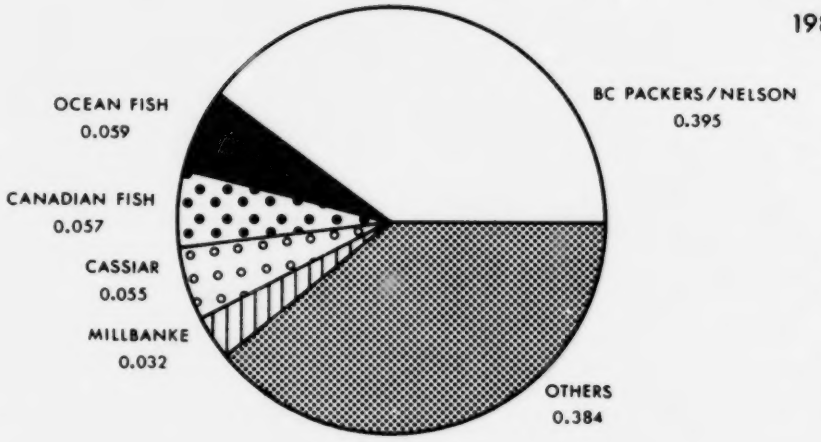
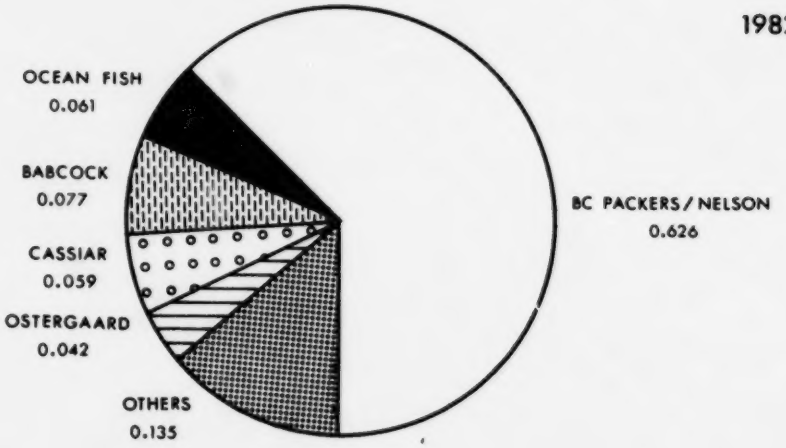

ESCAPEMENT
SEINE
GILLNET
OTHER GEAR
ABUNDANCE (millions)
2.0
1.5
1.0
0.5
0.0
1980
1981
1982
1983
1984
YEAR

Fig. 3. Proportion of Area 23 sockeye landings for all gear types by processor during weeks when Area 23 sockeye fishery open, 1980 to 1982, from DFO sales slip salmon landings database (F. Wong, DFO/PBS).

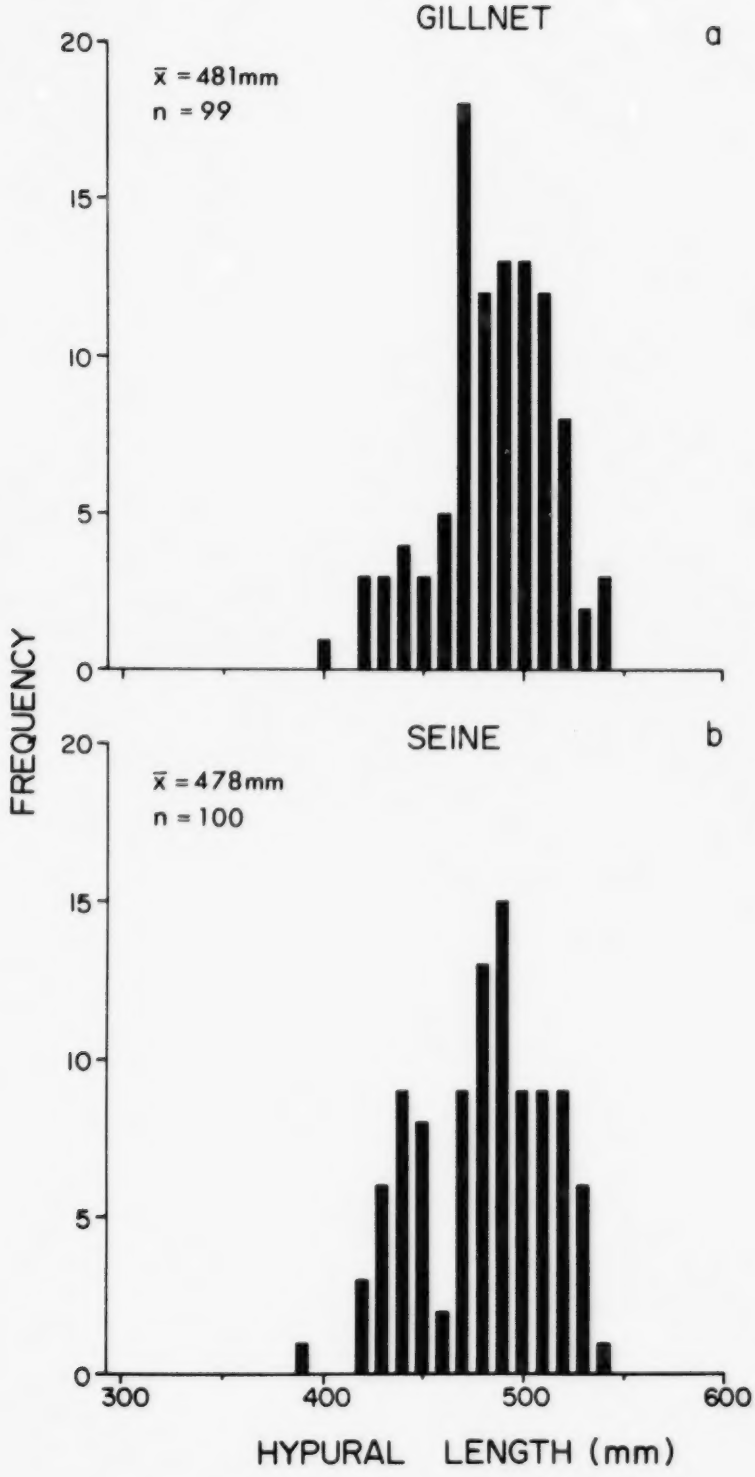

1980
OCEAN FISH
0.071
CANADIAN FISH
0.068
CASSIAR
0.053
MILLBANKE
0.032
OTHERS
0.246
BC PACKERS / NELSON
0.512


1981
OCEAN FISH
0.059
CANADIAN FISH
0.057
CASSIAR
0.055
MILLBANKE
0.032
OTHERS
0.384
BC PACKERS / NELSON
0.395

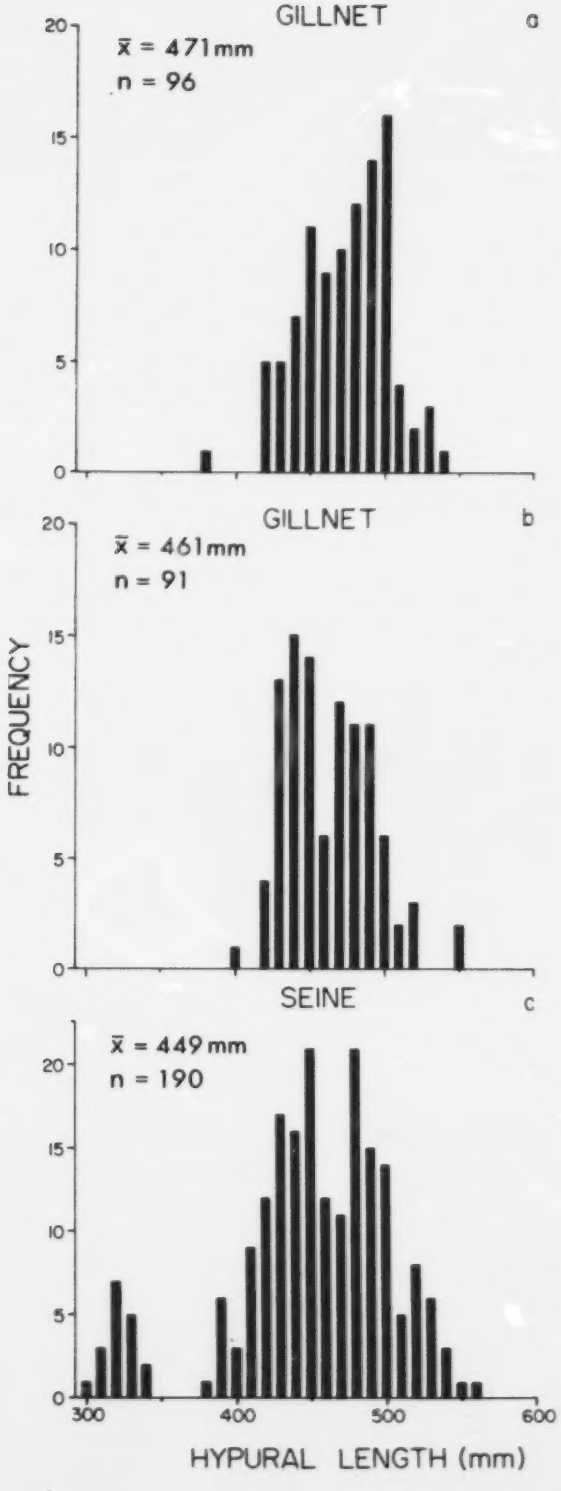

1982
OCEAN FISH
0.061
BABCOCK
0.077
CASSIAR
0.059
OSTERGAARD
0.042
OTHERS
0.135
BC PACKERS / NELSON
0.626

Appendix I. Post-orbital to hypural length frequency histograms for samples used in gear selectivity analyses.

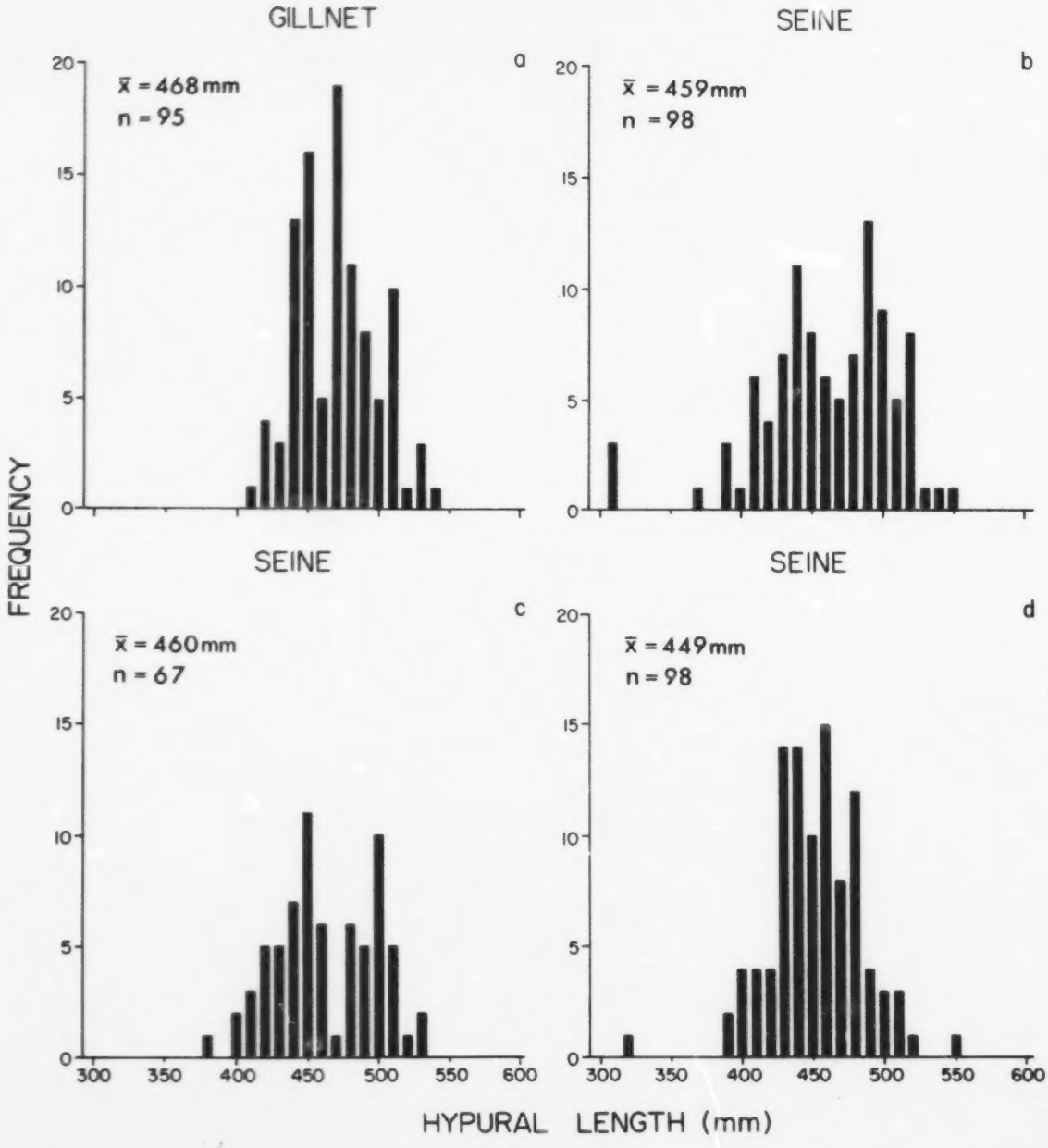
Appendix fig. 1. Gillnet sample 2 (a) and seine sample 1 (b) from the 07 June 1982 opening.


GILLNET
a
$\bar{x}$ = 481mm
n = 99
SEINE
b
$\bar{x}$ = 478mm
n = 100
FREQUENCY
HYPURAL LENGTH (mm)
0
5
10
15
20
300
400
500
600

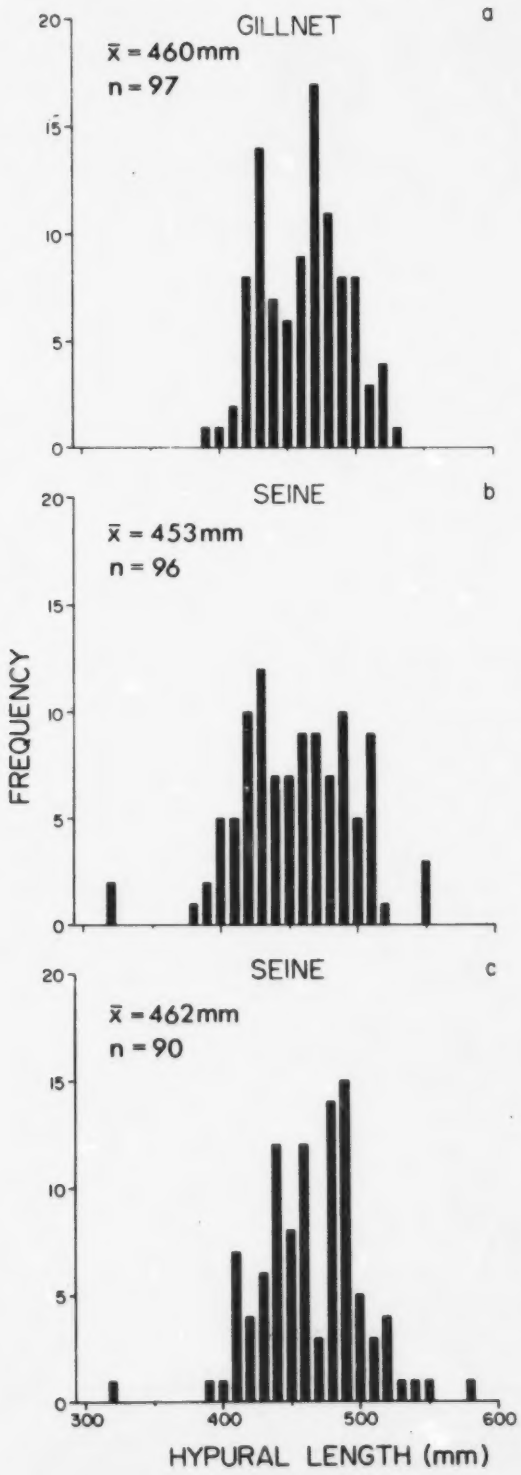
Appendix fig. 2. Gillnet samples 8 (a) and 9 (b) and seine sample 10 (c) from the 04 July 1982 opening.


GILLNET
a
x̄ = 471mm
n = 96
GILLNET
b
x̄ = 461mm
n = 91
SEINE
c
x̄ = 449mm
n = 190
FREQUENCY
HYPURAL LENGTH (mm)
0
5
10
15
20
300
400
500
600

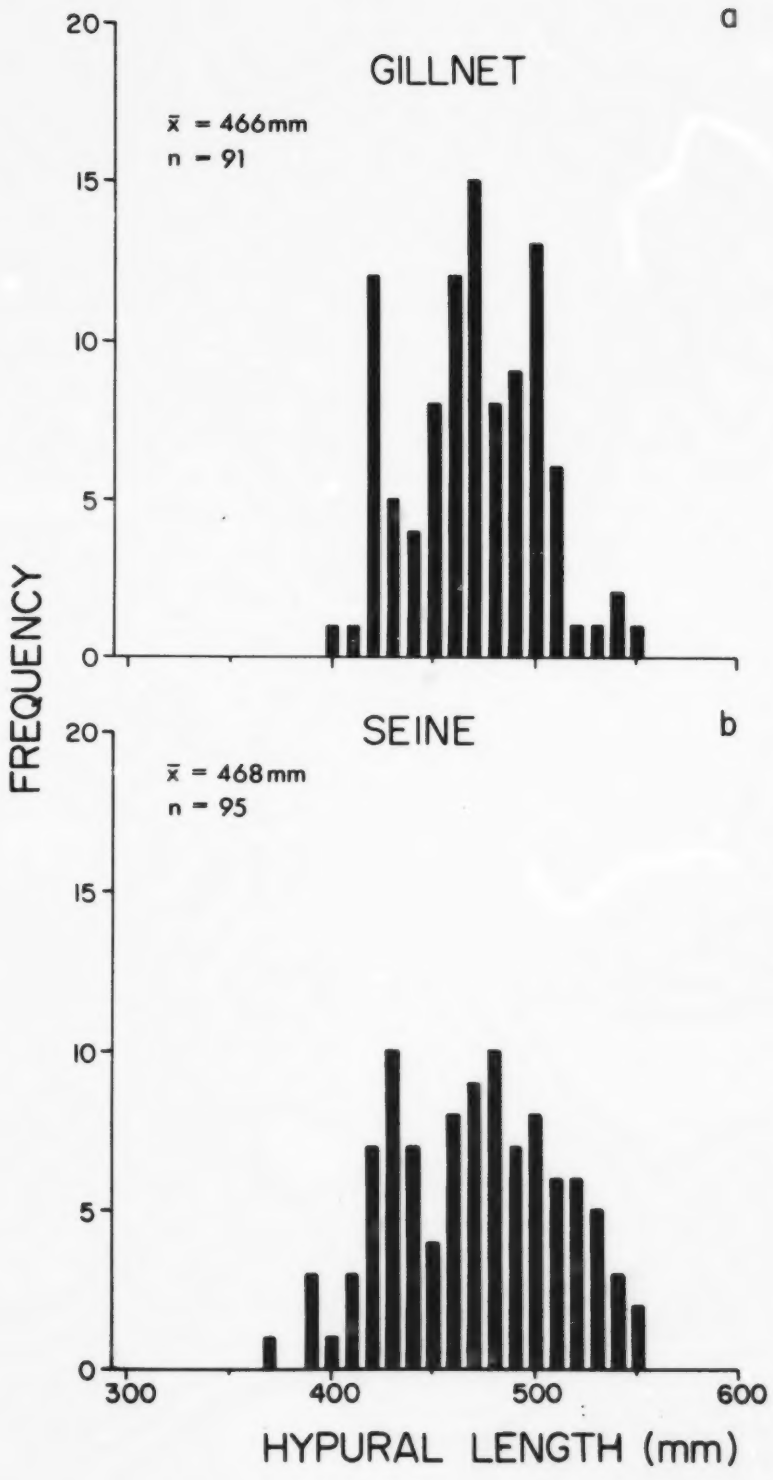
Appendix fig. 3. Gillnet sample 11 (a) and seine samples 12 (b), 13 (c), and 14 (d) from the 25 July 1983 opening.


GILLNET
a
$\bar{x}$ = 468mm
n = 95
SEINE
b
$\bar{x}$ = 459mm
n = 98
SEINE
c
$\bar{x}$ = 460mm
n = 67
SEINE
d
$\bar{x}$ = 449mm
n = 98
FREQUENCY
0
5
10
15
20
300
350
400
450
500
550
600
HYPURAL LENGTH (mm)

Appendix fig. 4. Gillnet sample 10 (a) and seine samples 9 (b) and 12 (c) from the 01 July 1984 opening.

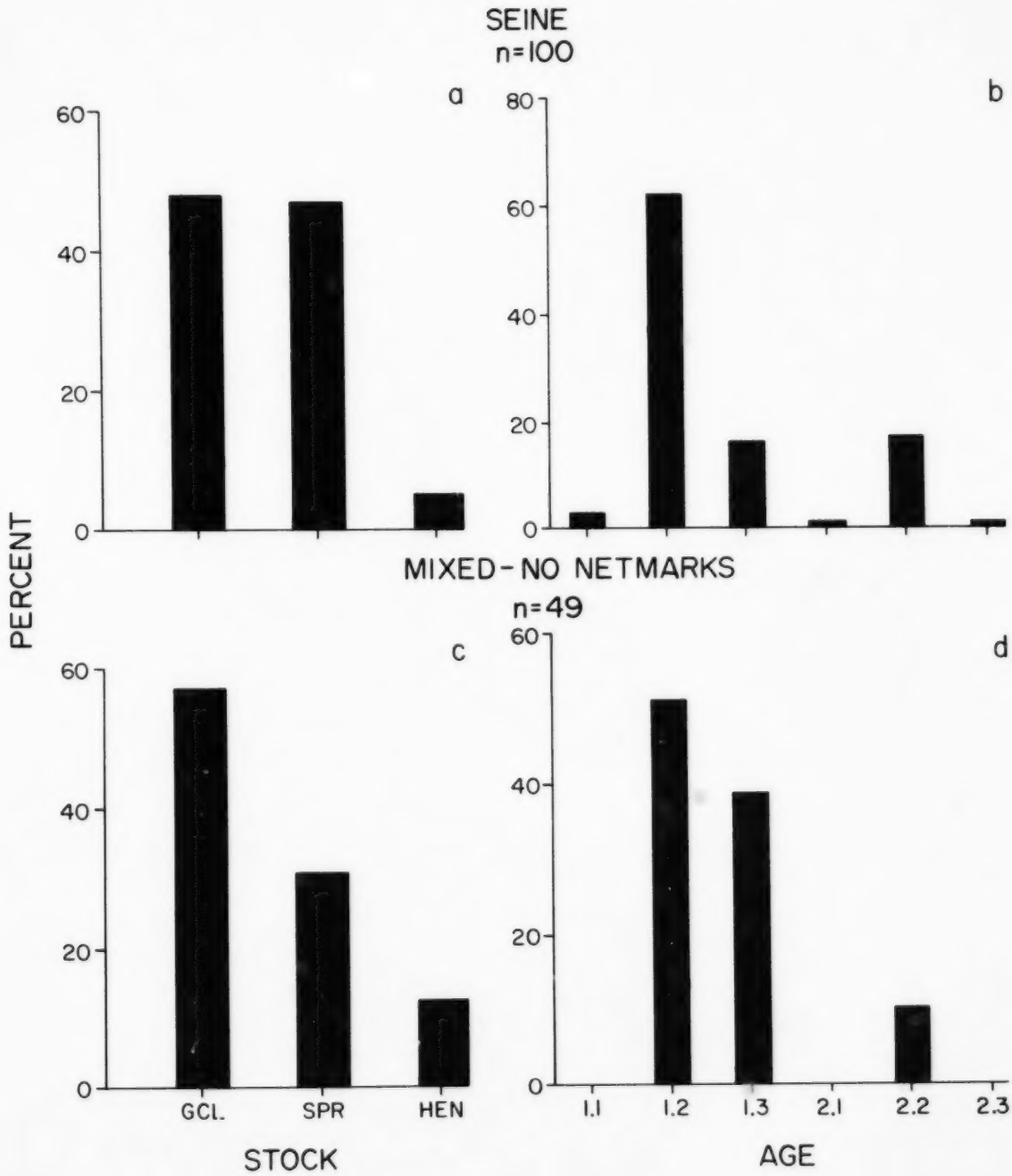

GILLNET
a
x̄ = 460mm
n = 97
SEINE
b
x̄ = 453mm
n = 96
SEINE
c
x̄ = 462mm
n = 90
FREQUENCY
0
5
10
15
20
300
400
500
600
HYPURAL LENGTH (mm)

Appendix fig. 5. Gillnet sample 13 (a) and seine sample 14 (b) from the 08 July 1984 opening.

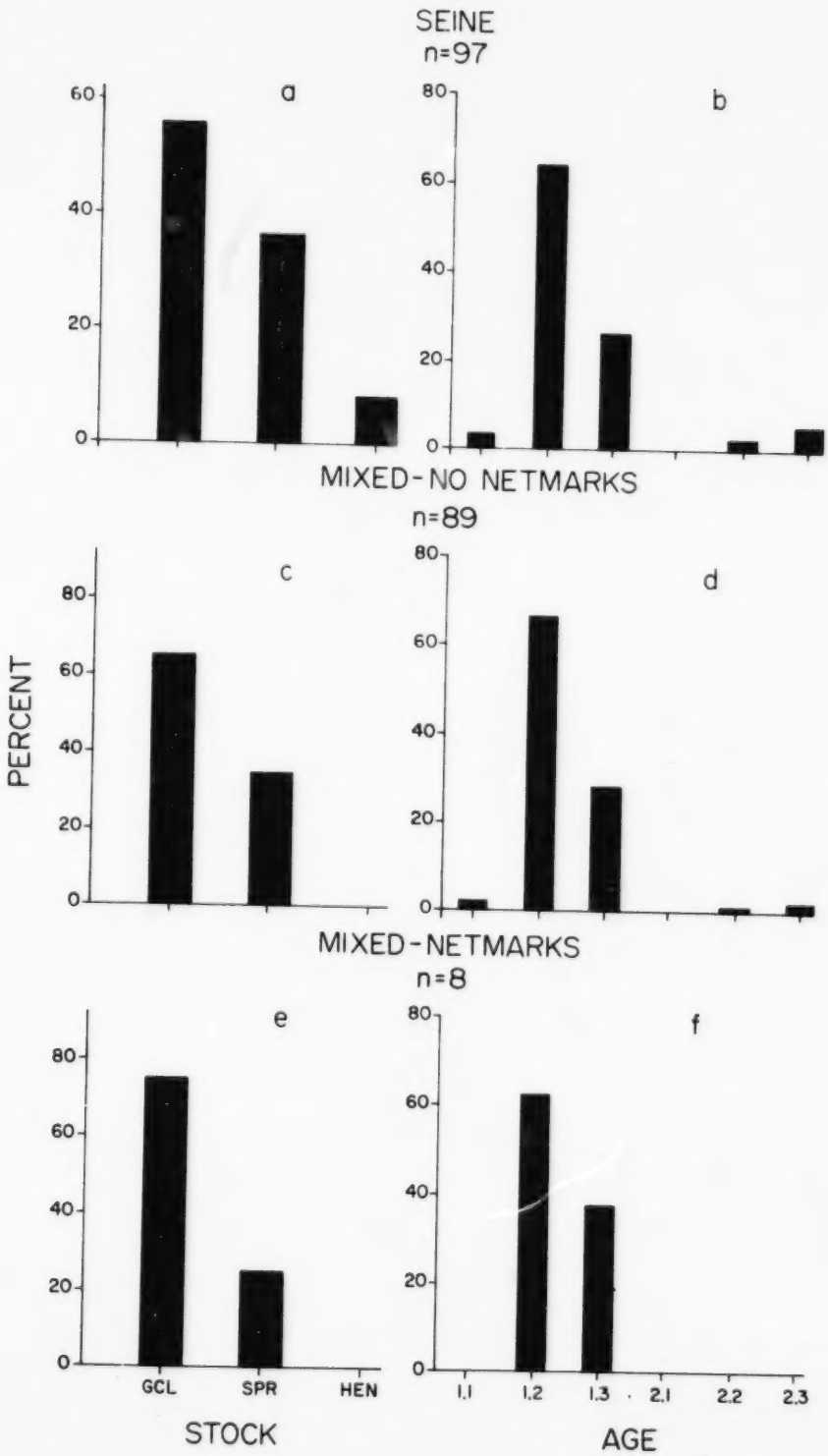

a
GILLNET
x̄ = 466mm
n = 91
b
SEINE
x̄ = 468mm
n = 95
FREQUENCY
0
5
10
15
20
300
400
500
600
HYPURAL LENGTH (mm)

Appendix II. Stock and age histograms of percent frequency by fishery opening date and sample.

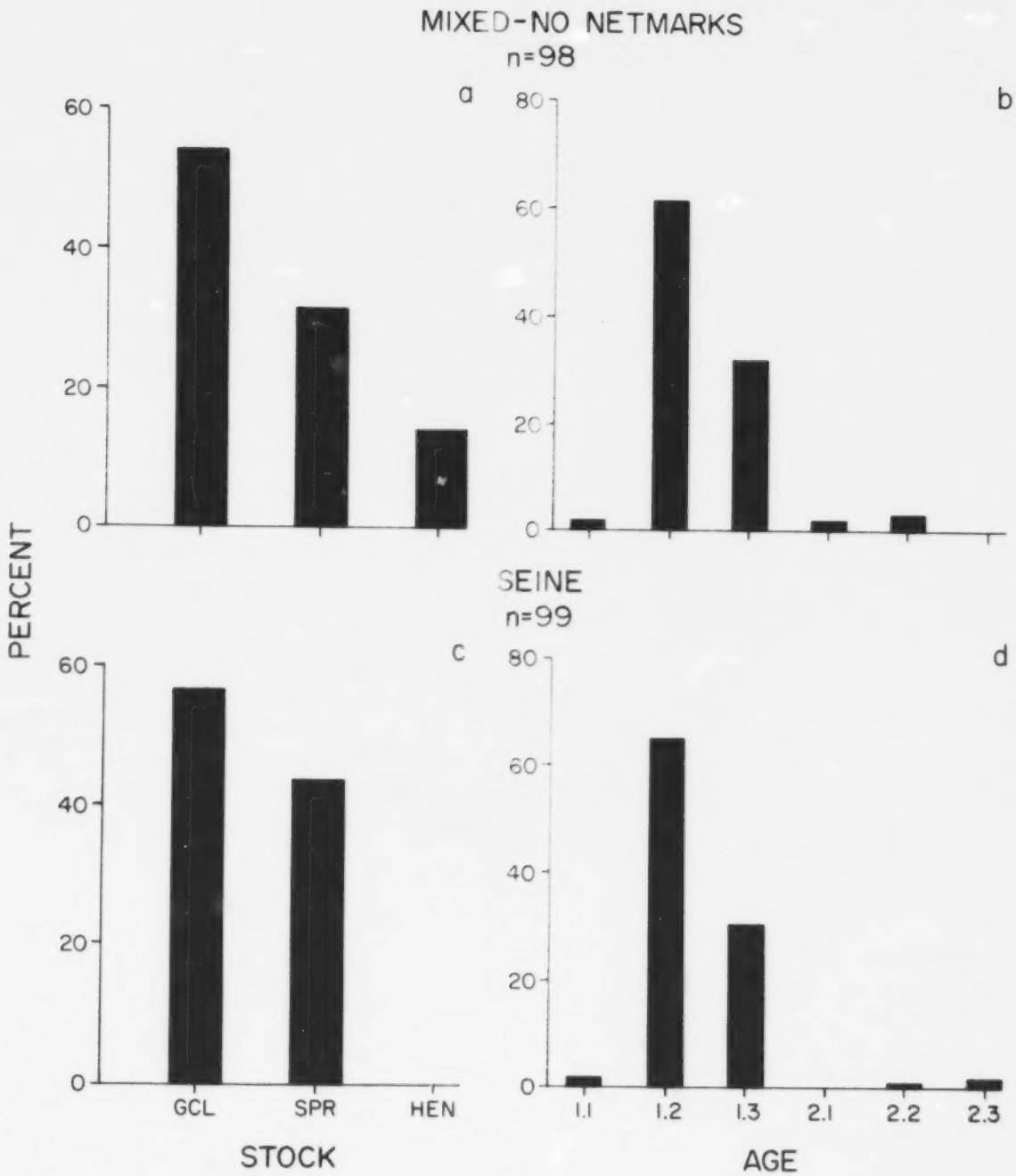
Appendix fig. 1. Seine sample 6 (a,b) and mixed gear sample 7 (c,d) from the 14 July 1980 opening.


SEINE
n=100
a
b
60
40
20
0
80
60
40
20
0
PERCENT
MIXED - NO NETMARKS
n=49
c
d
60
40
20
0
60
40
20
0
GCL.
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

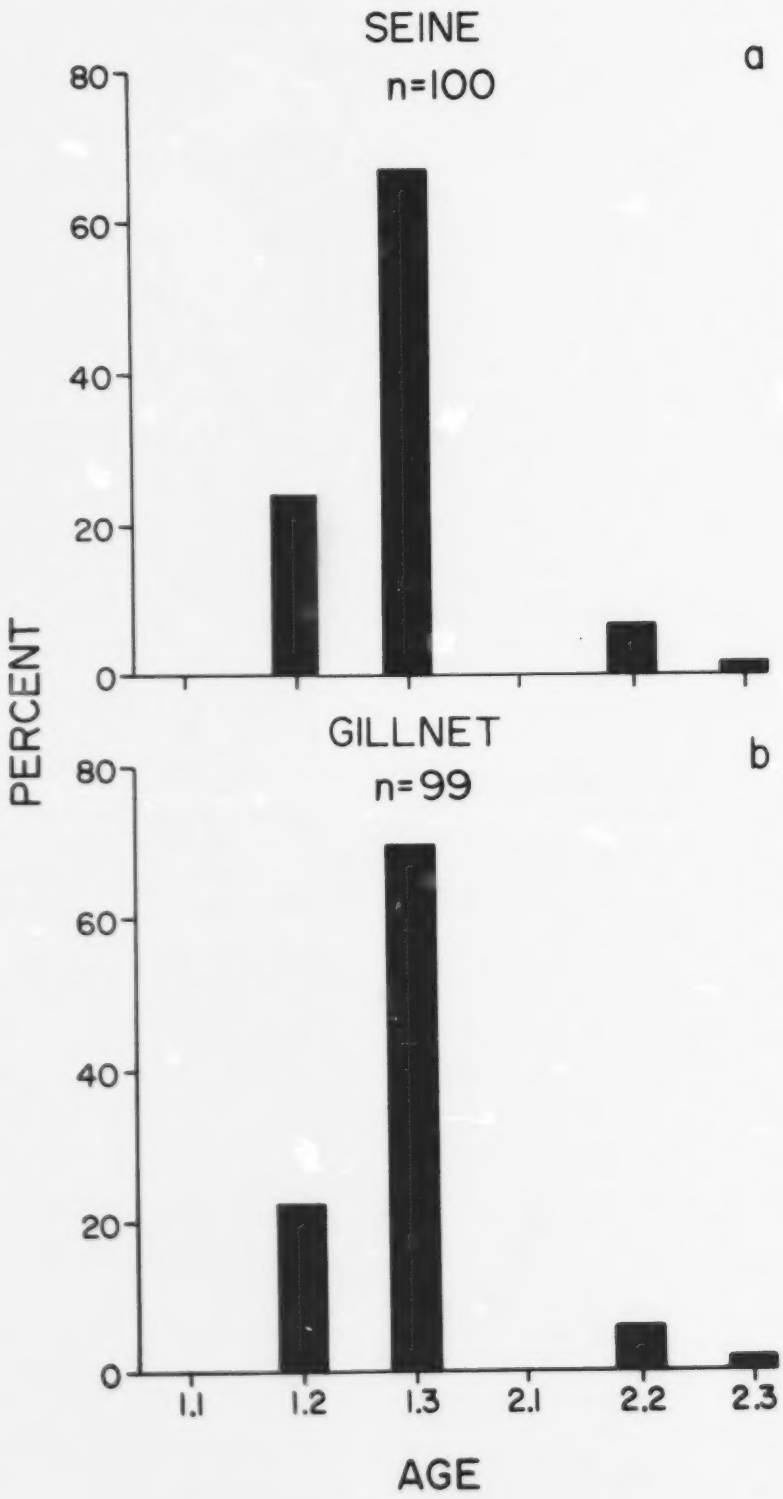
Appendix fig. 2. Seine sample 7 (a,b) and mixed gear sample 6 (c,d,e,f) from the 13 July 1981 opening.


SEINE
n=97
a
b
MIXED-NO NETMARKS
n=89
c
d
PERCENT
MIXED-NETMARKS
n=8
e
f
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

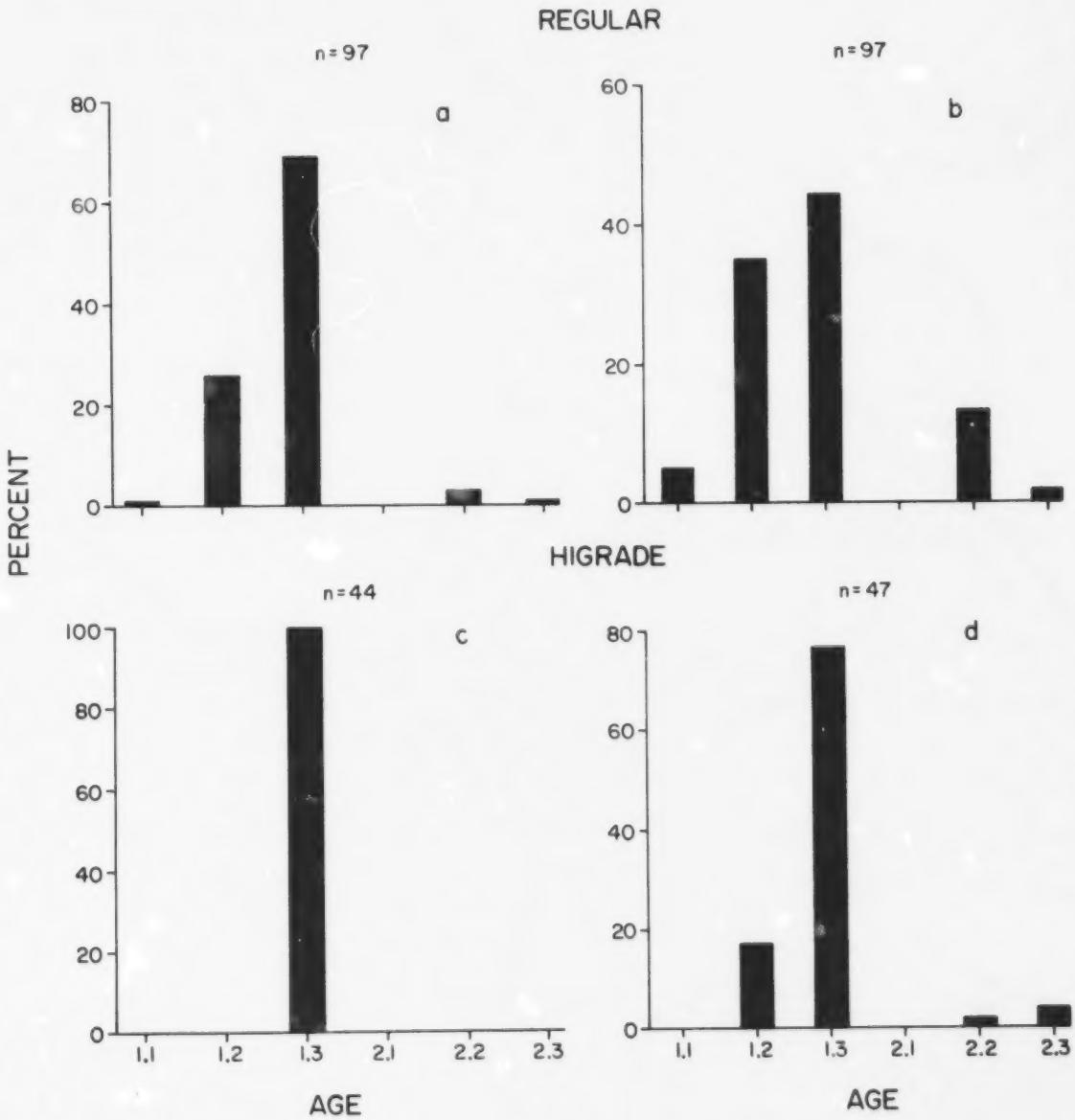
Appendix fig. 3. Mixed gear sample 8 (a,b) and seine sample 9 (c,d) from the 20 July 1981 opening.


MIXED-NO NETMARKS
n=98
a
b
SEINE
n=99
c
d
PERCENT
60
40
20
0
80
60
40
20
0
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

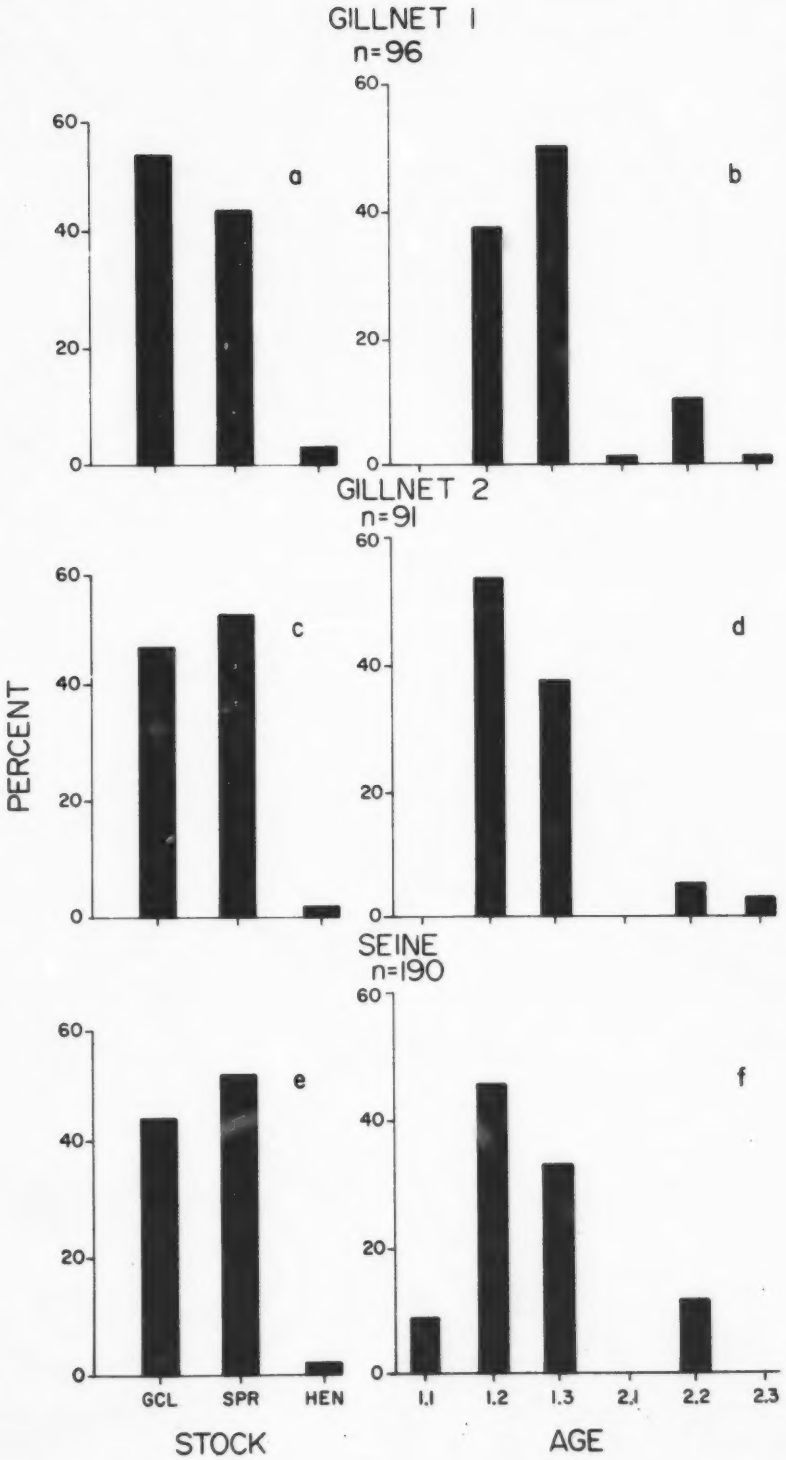
Appendix fig. 4. Seine sample 1 (a) and gillnet sample 2 (b) from the 07 June 1982 opening.


SEINE
n=100
a
80
60
40
20
0
PERCENT
GILLNET
n=99
b
80
60
40
20
0
1.1
1.2
1.3
2.1
2.2
2.3
AGE

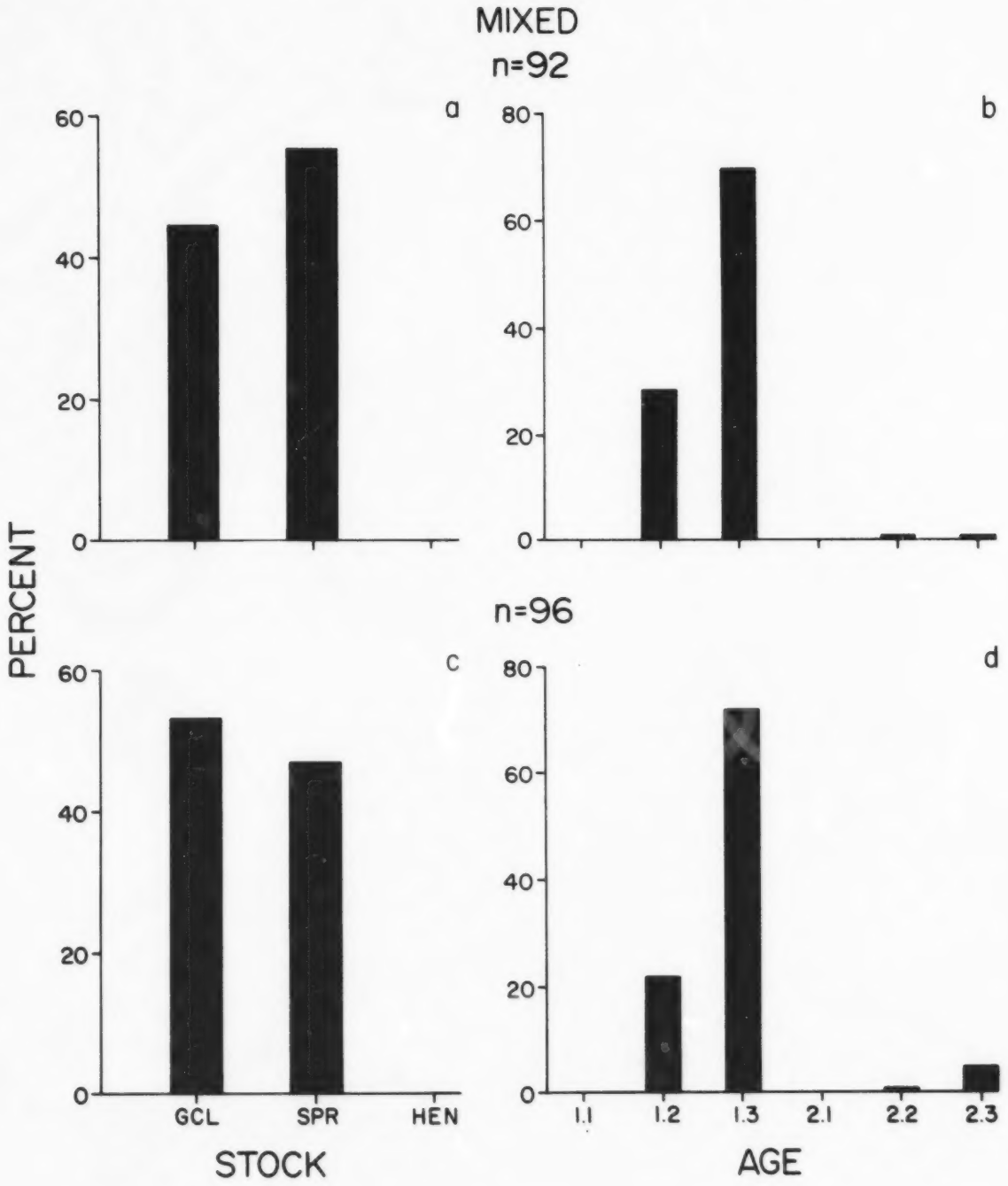
Appendix fig. 5. Regular samples 3 (a) and 5 (c) and higrade samples 4 (b) and 6 (d) from the 14 and 21 June 1982 openings.


REGULAR
n=97
n=97
a
b
PERCENT
HIGRADE
n=44
n=47
c
d
AGE
AGE
1.1
1.2
1.3
2.1
2.2
2.3

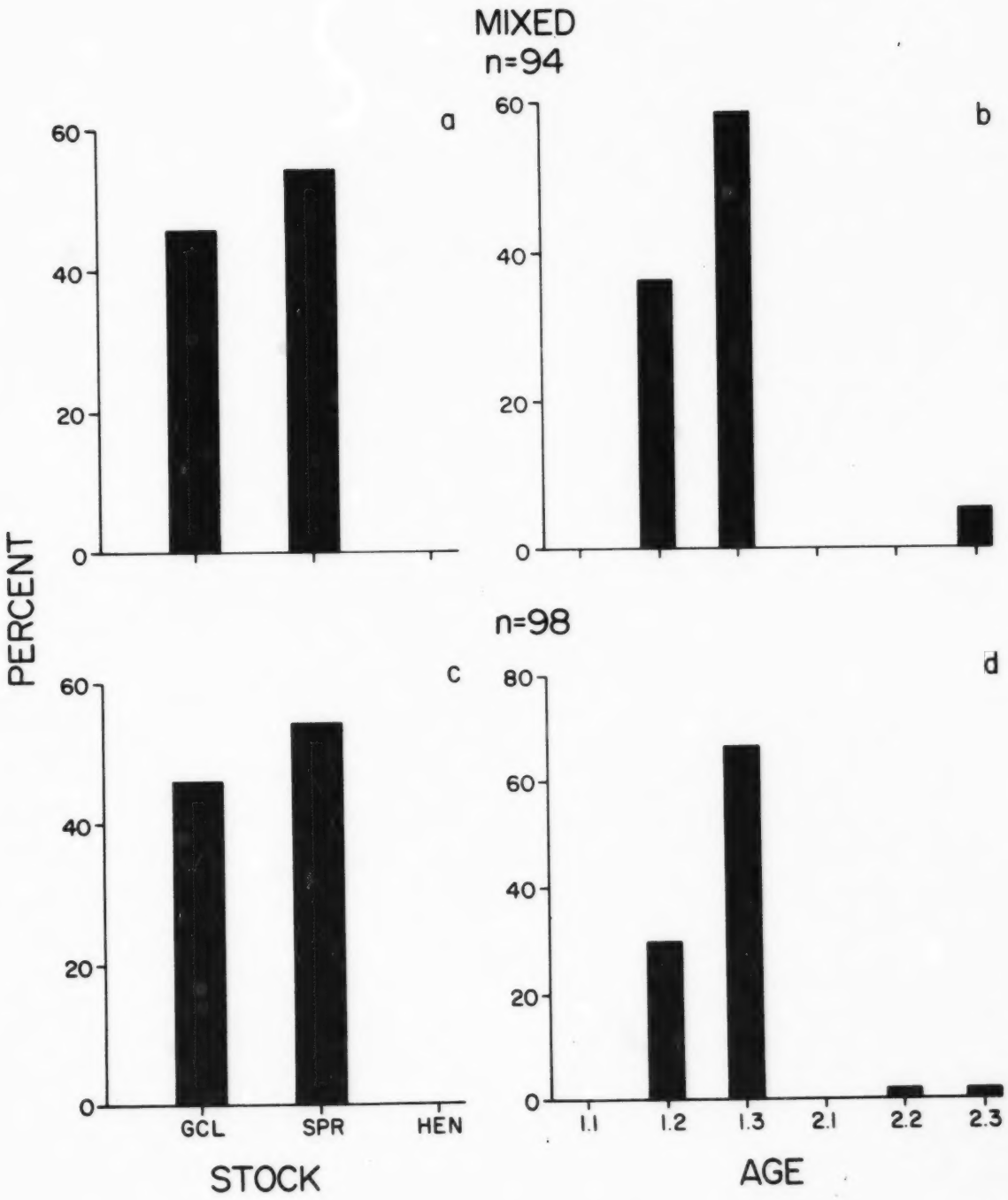
Appendix fig. 6. Gillnet samples 8 (a,b) and 9 (c,d) and seine sample 10 (e,f) from the 04 July 1982 opening.


GILLNET 1
n=96
GILLNET 2
n=91
SEINE
n=190
PERCENT
a
b
c
d
e
f
0
20
40
60
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

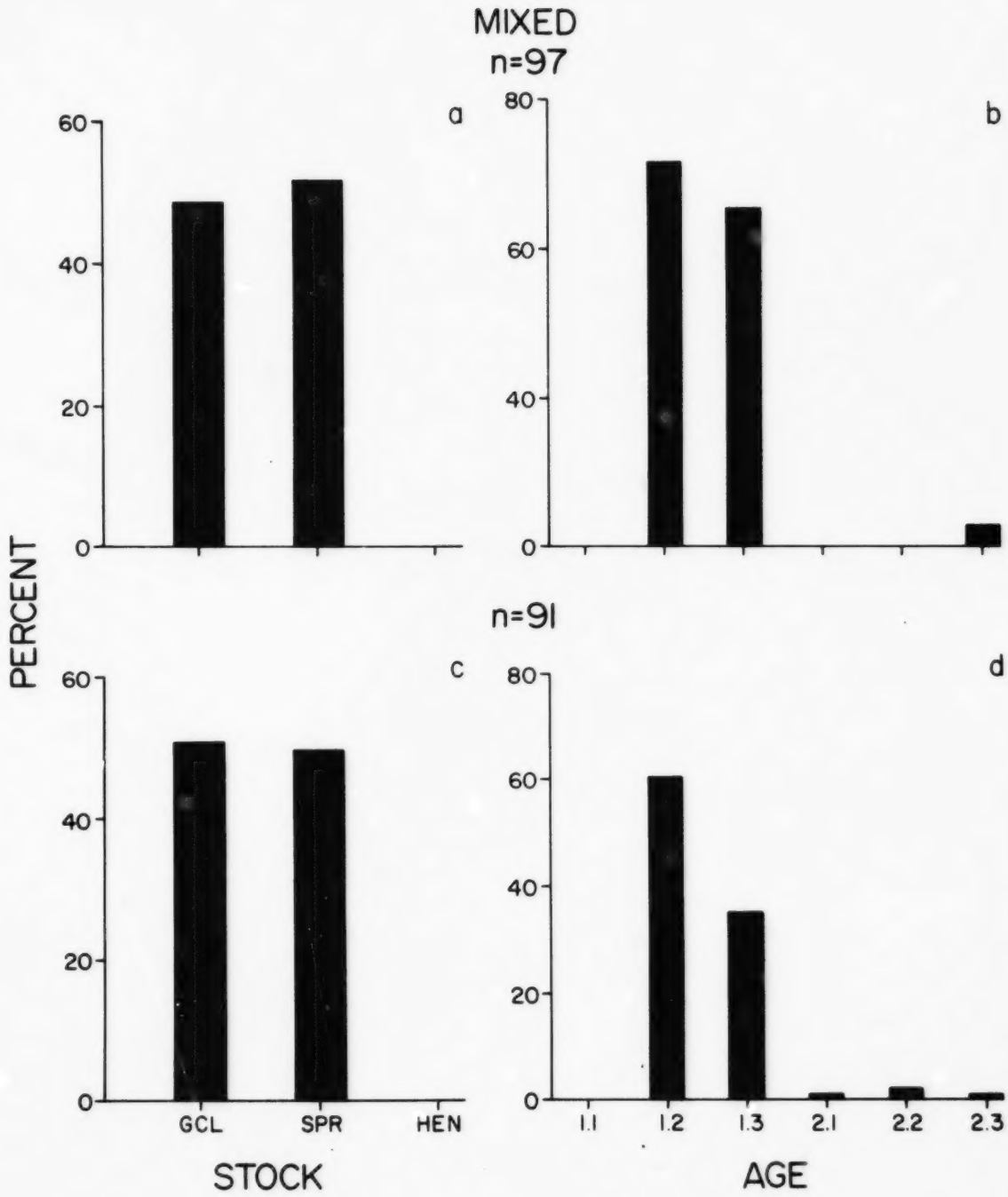
Appendix fig. 7. Mixed gear samples 1 (a,b) and 2 (c,d) from the 06 June 1983 opening.


MIXED
n=92
a
b
n=96
c
d
PERCENT
60
40
20
0
80
60
40
20
0
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

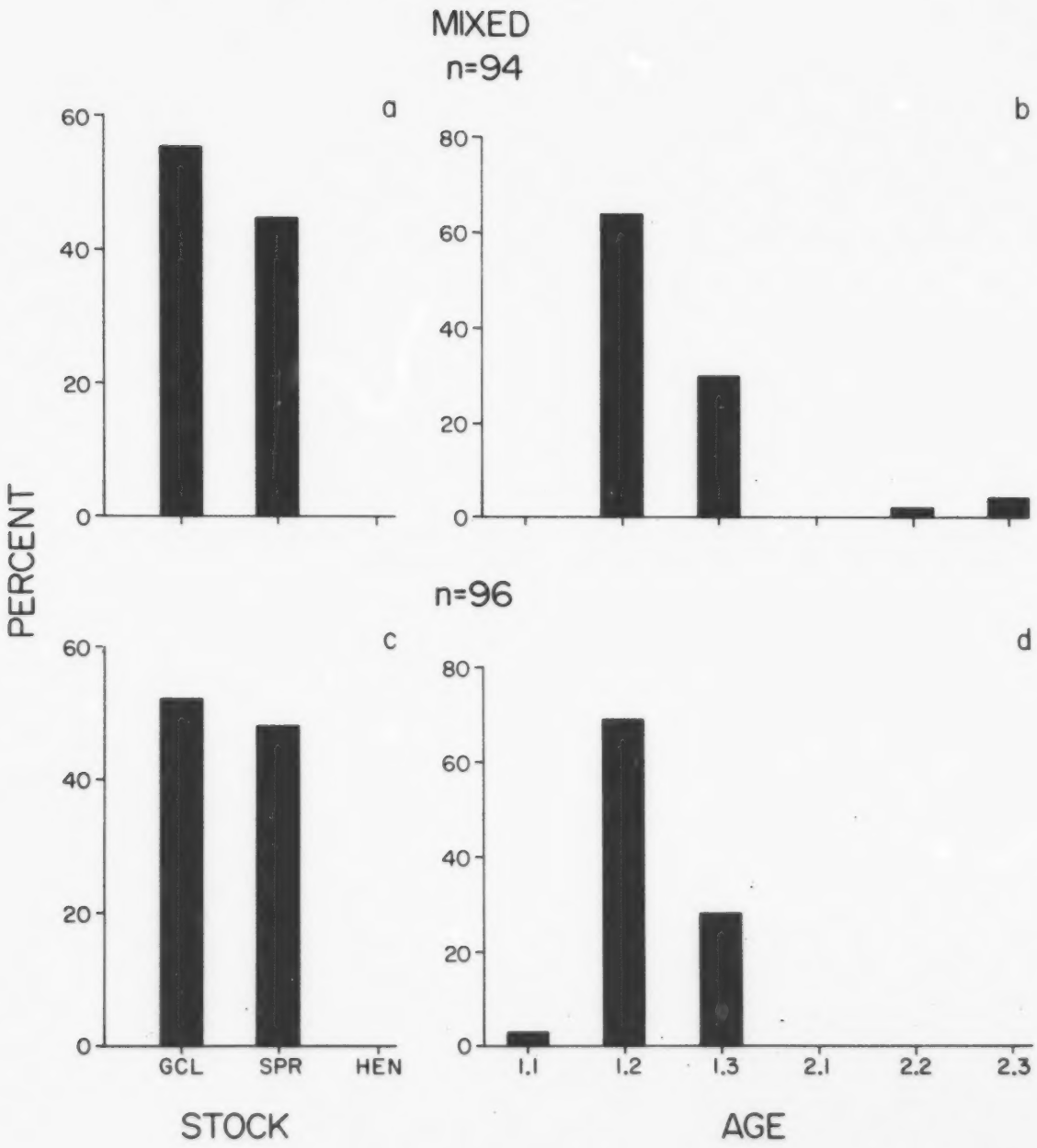
Appendix fig. 8. Mixed gear samples 3 (a,b) and 4 (c,d) from the 13 June 1983 opening.


MIXED
n=94
a
b
n=98
c
d
PERCENT
60
40
20
0
80
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

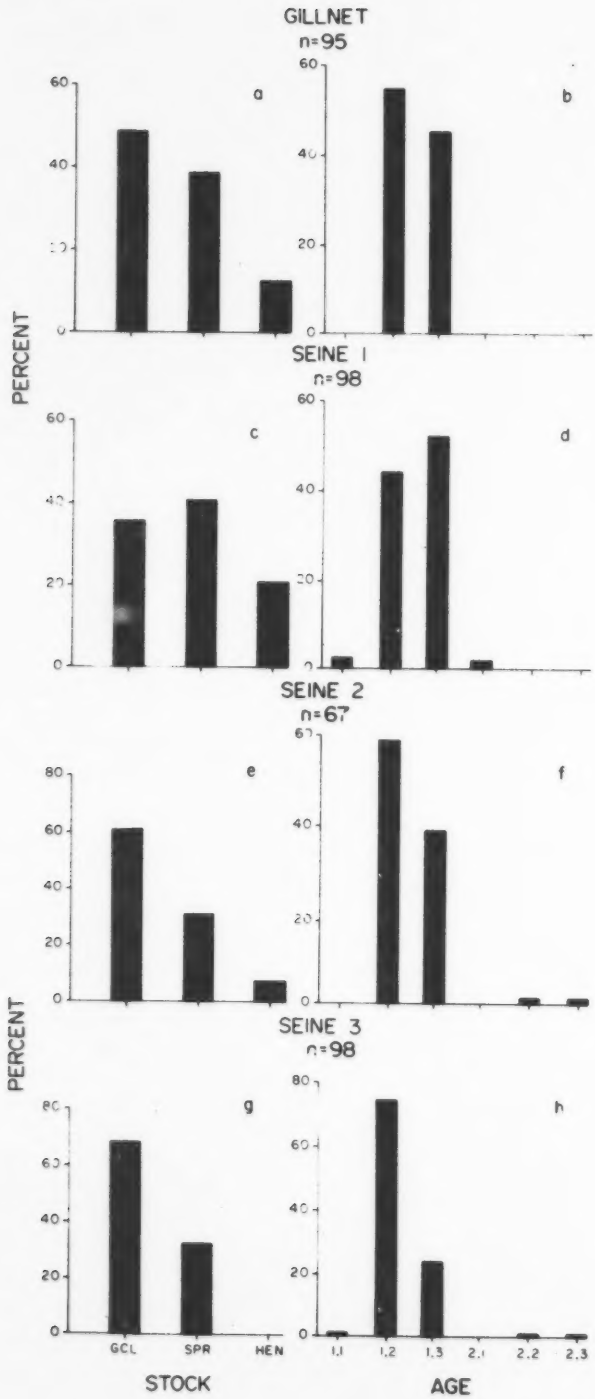
Appendix fig. 9. Mixed gear samples 5 (a,b) and 6 (c,d) from the 20 June 1983 opening.


MIXED
n=97
a
b
n=91
c
d
PERCENT
60
40
20
0
80
60
40
0
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

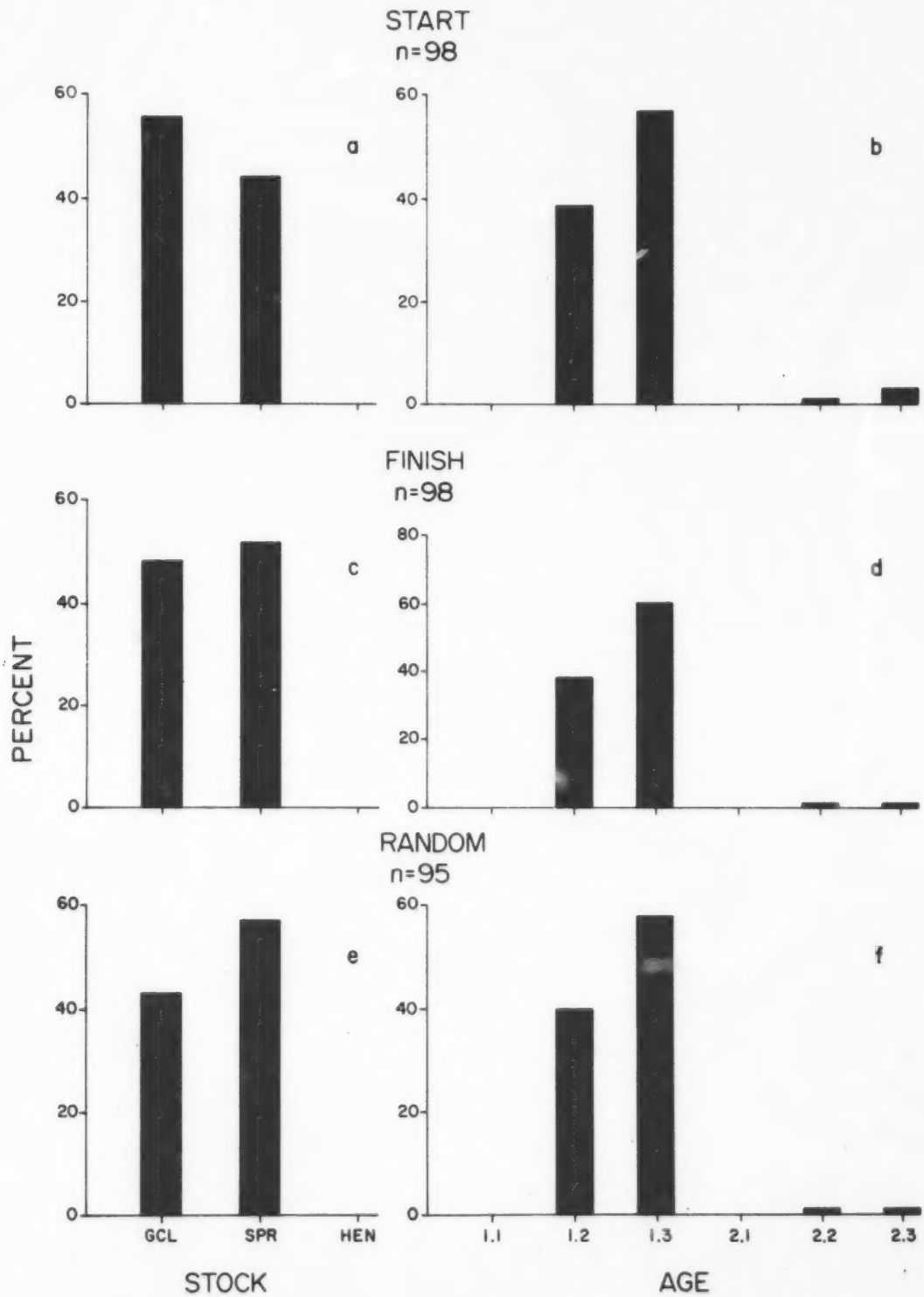
Appendix fig. 10. Mixed gear samples 7 (a,b) and 8 (c,d) from the 27 June 1983 opening.


MIXED
n=94
a
b
n=96
c
d
PERCENT
60
40
20
0
80
60
40
20
0
GCL
SPR
HEN
1.1
1.2
1.3
2.1
2.2
2.3
STOCK
AGE

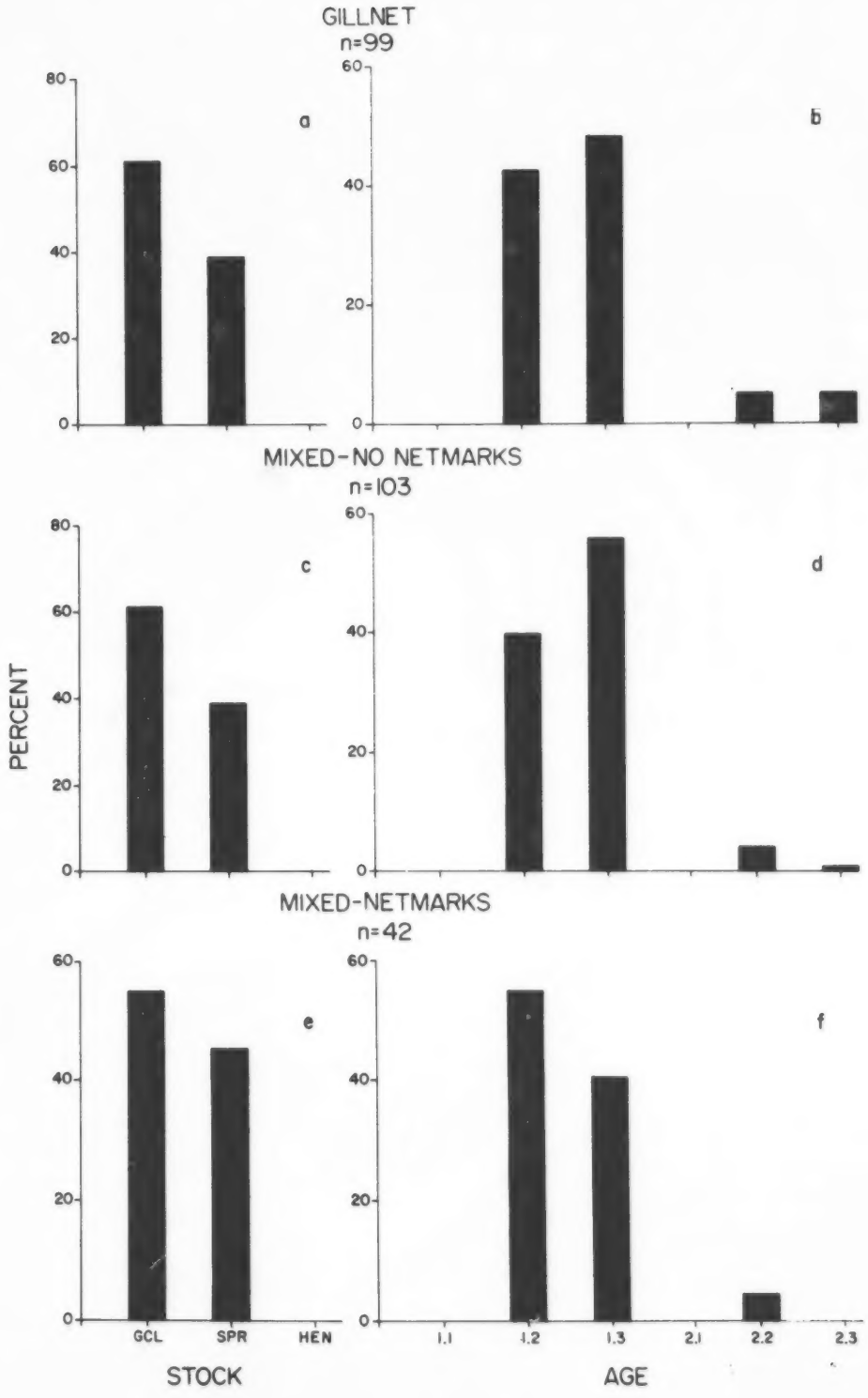
Appendix fig. 11. Gillnet sample 11 (a,b) and seine samples 12 (c,d), 13 (e,f) and 14 (g,h) from the 25 July 1983 opening.


GILLNET
n=95
a
b
SEINE 1
n=98
c
d
SEINE 2
n=67
e
f
SEINE 3
n=98
g
h
PERCENT
PERCENT
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

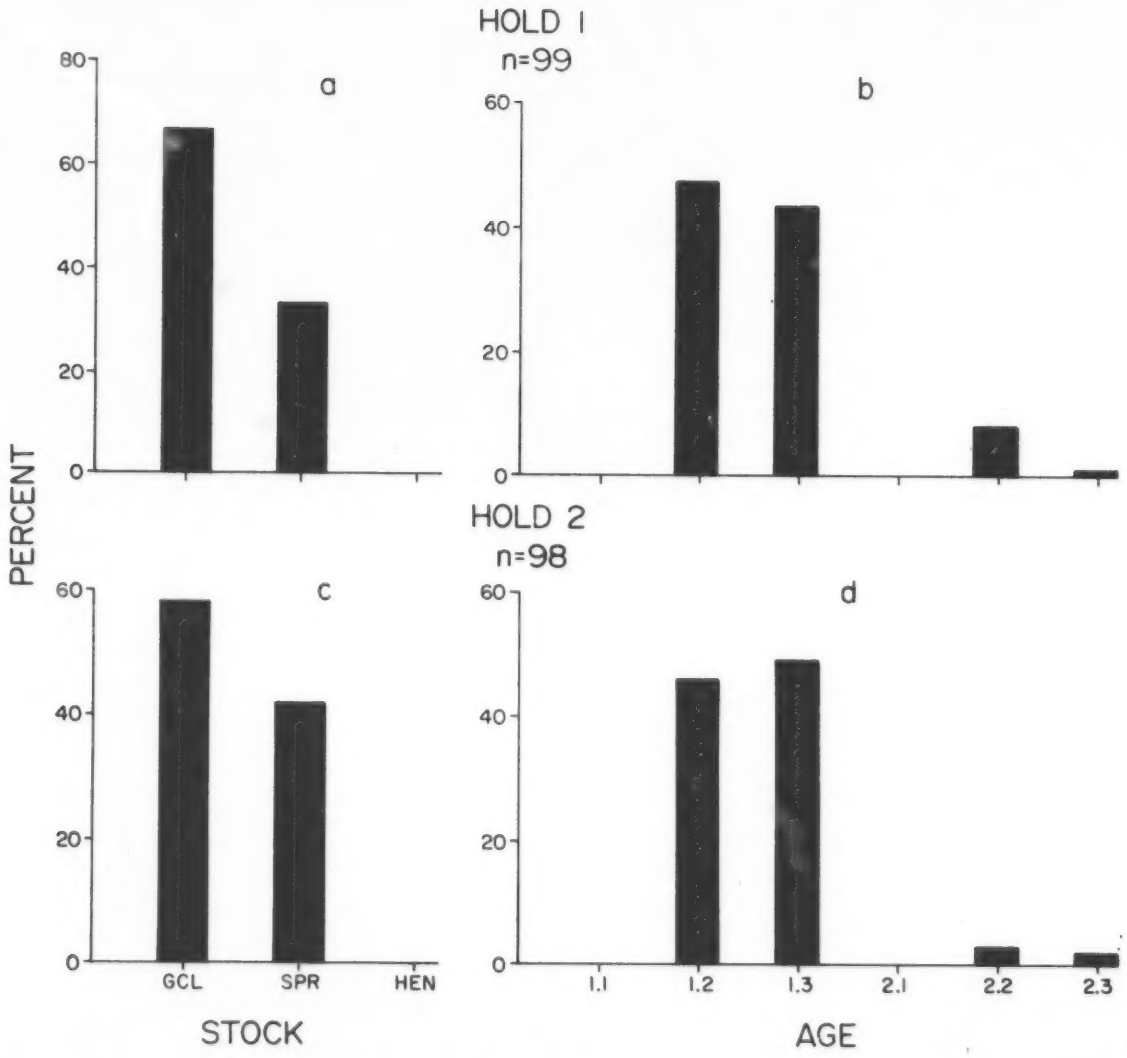
Appendix fig. 12. Samples 1 (a,b), 2 (c,d) and 3 (e,f) taken from the beginning, the end and randomly throughout a processing run from the 03 June 1984 opening.


START
n=98
a
b
FINISH
n=98
c
d
RANDOM
n=95
e
f
PERCENT
0
20
40
60
80
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

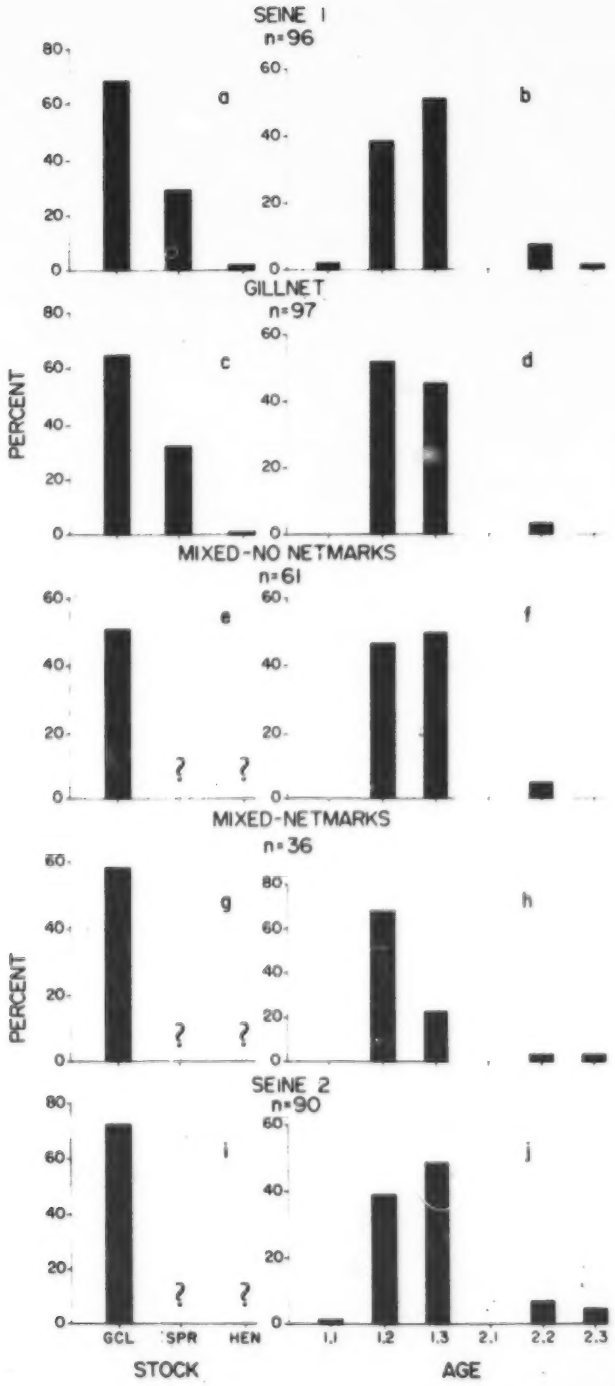
Appendix fig. 13. Gillnet sample 5 (a,b) and mixed gear sample 6 (c,d,e,f) from the 17 June 1984 opening.


GILLNET
n=99
a
b
MIXED-NO NETMARKS
n=103
c
d
MIXED-NETMARKS
n=42
e
f
PERCENT
0
20
40
60
80
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

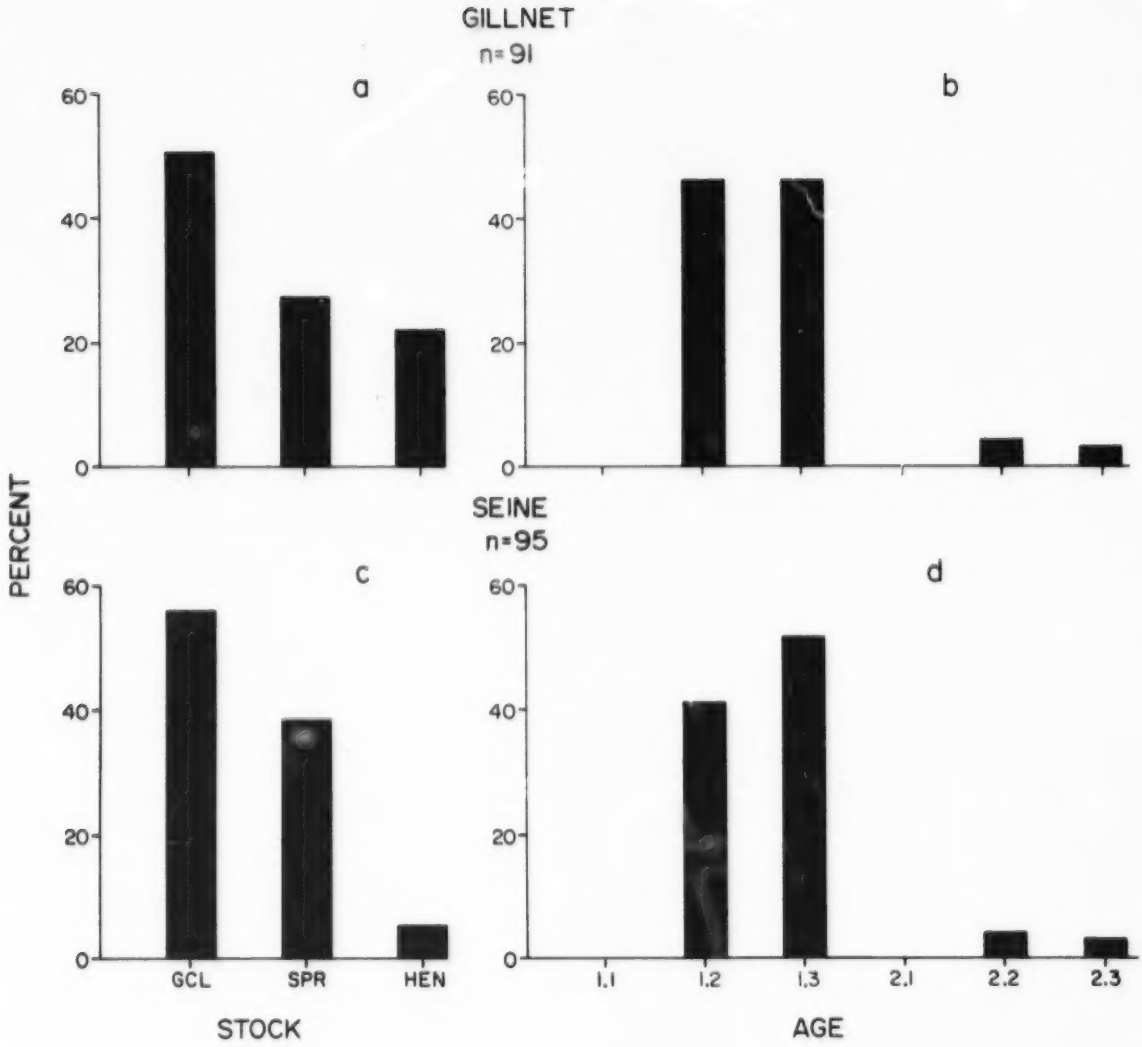
Appendix fig. 14. Samples 8 (a,b) and 7 (c,d) from holds 1 and 2, respectively, from the 24 June 1984 opening.


HOLD 1
n=99
HOLD 2
n=98
a
b
c
d
PERCENT
80
60
40
20
0
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

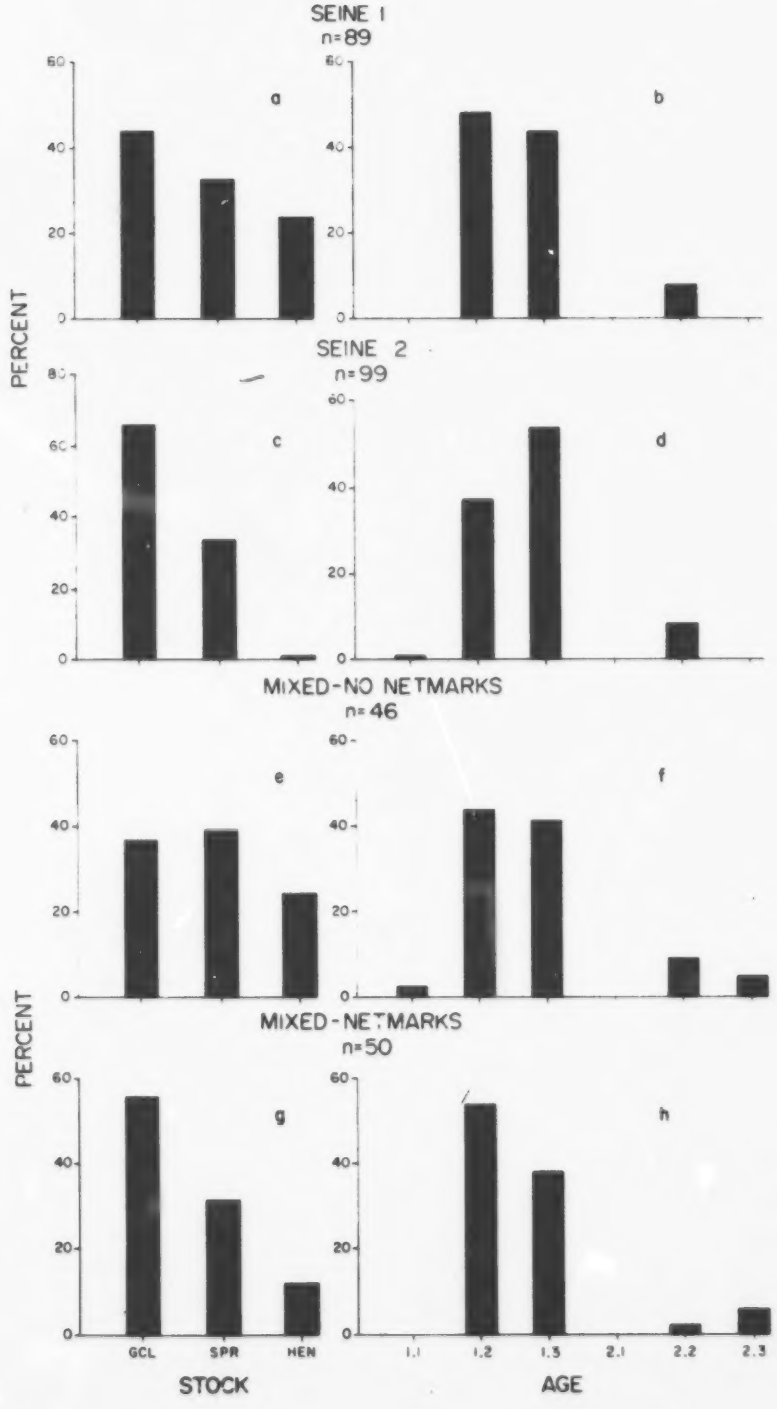
Appendix fig. 15. Seine sample 9 (a,b), gillnet sample 10 (c,d), mixed gear sample 11 (e,f,g,h) and seine sample 12 (i,j) from the 01 July 1984 opening. Henneguya sp. incidence data were not collected from samples 11 and 12 so the proportions of Sproat and Henderson sockeye in those samples can not be calculated.


SEINE 1
n=96
a
b
GILLNET
n=97
c
d
PERCENT
MIXED-NO NETMARKS
n=61
e
f
MIXED-NETMARKS
n=36
g
h
PERCENT
SEINE 2
n=90
i
j
GCL
SPR
HEN
1.1
1.2
1.3
2.1
2.2
2.3
STOCK
AGE

Appendix fig. 16. Gillnet sample 13 (a,b) and seine sample 14 (c,d) from the 08 July 1984 opening.


GILLNET
n=91
a
b
SEINE
n=95
c
d
PERCENT
60
40
20
0
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE

Appendix fig. 17. Seine samples 15 (a,b) and 16 (c,d) and mixed gear sample 17 (e, f, g, h) from the 16 July 1984 opening.


SEINE 1
n=89
a
b
SEINE 2
n=99
c
d
MIXED-NO NETMARKS
n=46
e
f
MIXED-NETMARKS
n=50
g
h
PERCENT
0
20
40
60
80
GCL
SPR
HEN
STOCK
1.1
1.2
1.3
2.1
2.2
2.3
AGE